SCIENCE

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SCIENCE: A Weekly Journal, since 1900 the official organ of the American Association for the Advancement of Science. Published by the American Association for the Advancement of Science every Friday at Lancaster, Pennsylvania.

Editors: JOSEPHINE OWEN CATTELL and JAQUES CATTELL.

Policy Committee: MALCOLM H. SOULE, ROGER ADAMS and WALTER R. MILES.

Advertising Manager: THEO. J. CHRISTENSEN.

Communications relative to articles offered for publication should be addressed to Editors of Science, The Science Press, Lancaster, Pa.

Communications relative to advertising should be addressed to THEO. CHRISTENSEN, Advertising Manager, American University, 3801 Nebraska Ave., NW, Washington 16, D. C.

Communications relative to membership in the Association and to all matters of business of the Association should be addressed to the Permanent Secretary, A.A.A.S., Smithsonian Institution Building, Washington 25, D. C.

Annual subscription, $6.00 Single copies, 15 cents

VISIBLE PATTERNS OF SOUND

By RALPH K. POTTER

BELL TELEPHONE LABORATORIES

THE automatic representation of speech sounds by visible traces or symbols has long been a subject of interest to acousticians and phoneticians, and especially to those concerned with the development of electrical communication. Techniques for automatically recording the wave forms of sounds have been very highly developed; but there has remained unsolved, until recently, the problem of recording sounds in a manner permitting their ready visual interpretation and correlation with the auditory sense. An outstanding difficulty with the interpretation of the records of wave forms is the effect of phase relationships between fundamental and harmonics. These effects may produce a marked difference in the appearance of the wave forms of two sounds that are quite indistinguishable to the ear. Consequently, wave traces of even simple vowel sounds do not permit of easy identification by the eye.

The facts are that wave traces contain too much information. To portray sound in a form that the eye can encompass in a glance requires that some means be provided for selecting the essential information and displaying it in an orderly fashion. A form of display that meets these requirements has been developed in the Bell Telephone Laboratories as described below.

The work here described was begun before the war. Because of related war interests it was given official rating as a war project, and has progressed far enough during the war period to justify its being brought now to public attention.

The possible uses of an automatic system for translating sound into patterns which may be readily interpreted by the eye are very numerous. It opens the prospect of some day enabling totally deaf or severely deafened persons to use the telephone and the radio or to carry on direct conversation by visual hearing. [The latter, incidentally, was an objective

of the early researches of Alexander Graham Bell.] It suggests the possibility of printing words phonetically and of the automatic retranslation of such printed symbols into understandable sound. It opens the way to the selective operation of automatic devices by voice sounds. It promises to be particularly useful in the specialized fields of phonetics, philology and music. But most immediately, and from humane considerations most importantly, it opens a new avenue of help to the totally and severely deafened—help to learn to speak, and for those who already speak, help to improve their speech. It is to this problem of aid to the deaf that we have first directed our efforts.

It is too early to evaluate the results of these efforts with certainty. That there is a firm basis underlying the legibility of the visible speech patterns which have been obtained can hardly be doubted, but many questions remain concerning the design of practical translating equipment, the time and effort necessary to acquire a reading vocabulary, the effects of transmission and reception conditions on pattern legibility, and the special needs of the equipment for speech teaching and rehabilitation. These questions can not and should not be answered hastily, even though they are naturally urgent to those afflicted with a serious hearing loss. Their answering requires, during the developmental stages of the equipment, the cooperative efforts of the engineer and the groups concerned with the problems of deafness. The purpose of the present paper is to introduce the subject of visible patterns of sound and to describe briefly some of the more general aspects of the work with them.

In Fig. 1 are shown two forms of the new sound patterns. Both represent the same words—"This is visible speech"—and both show the three basic dimensions of sound—frequency, time, and intensity. It should be noted that the words associated with the different sections of the pattern, are inserted at the top of the figure. Time extends horizontally, the total length of each record being roughly 2½ seconds. Frequency is spread out vertically from substantially zero at the bottom of each record to about 3,500 cycles at the top. Intensity is shown by the varying shades of gray. Resolution of the frequency dimension is the significant difference between this and other more familiar displays of sound such as the oscillogram. Such a display provides for the eye the frequency analysis which is natural in aural perception and necessary for an understanding of sounds.

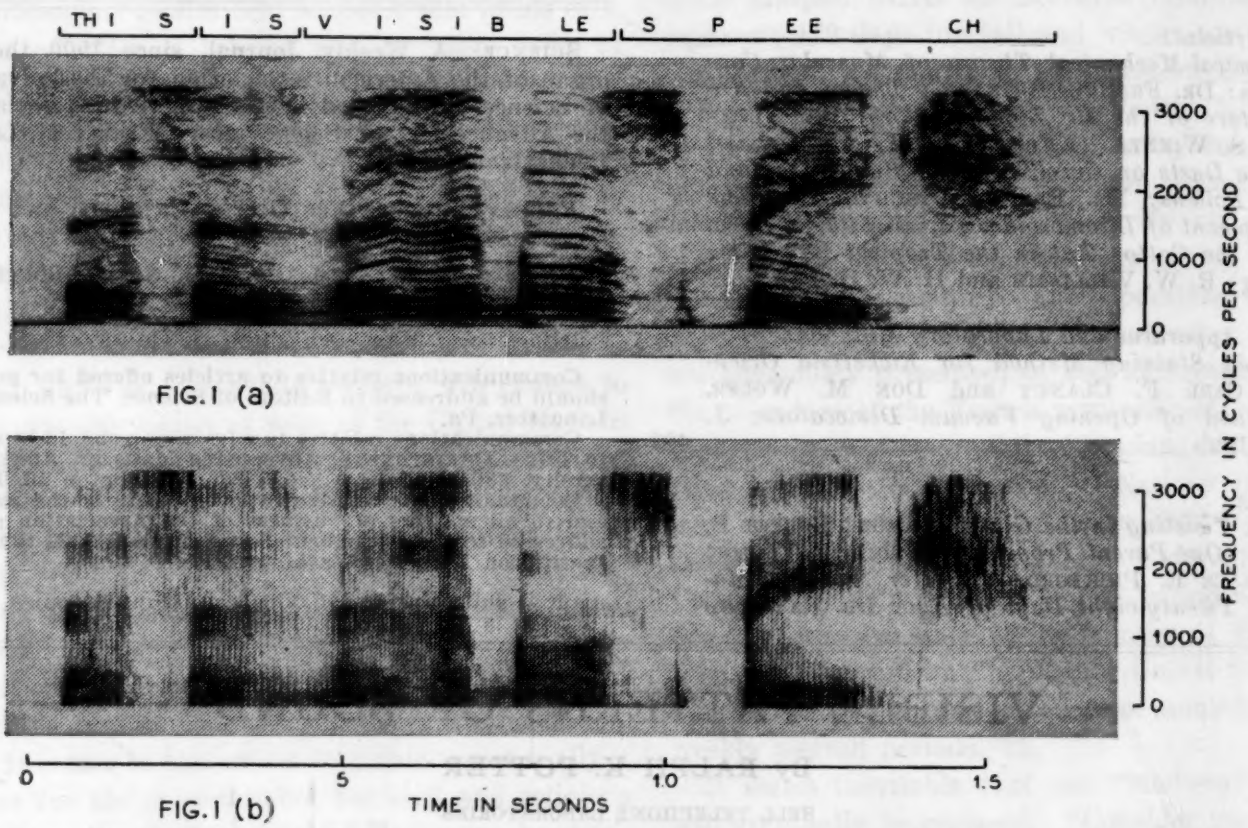

FIG. 1(a). High-detail sound spectrogram of the words "This is visible speech," showing the darker regions of mouth cavity resonance superimposed upon the detail of harmonics in voiced sounds.

FIG. 1(b). Low-detail sound spectrogram of the same words, showing the resonant regions as dark bands and eliminating detail.

Patterns of the type illustrated by Fig. 1(a) are of interest in studies of speech characteristics, while the type shown in Fig. 1(b) are of interest in visual hearing and phonetics. The former pattern shows the frequency composition in great detail, so that the individual harmonics of voiced sounds may be seen, and the manner in which the frequency of the harmonics varies with time. Patterns of the second type show only the broad frequency and time distri-

bution of energy resulting from selective modulation. It is such modulation, produced by variations in the voice cavities accompanying the formation of word sounds, that conveys the information in speech. Incidentally, the vertical striations appearing in Fig. 1(b) are produced by beats between adjacent harmonics so that in the voiced parts their density or frequency of occurrence is a measure of pitch, increasing as the pitch increases.

The patterns of Fig. 1 and others described later were made by an instrument that we have called the sound spectrograph. In this instrument, the sound to be pictured is recorded initially on a loop of magnetic tape and played back repeatedly into a scanning filter, the pass band of which is moved slowly across the frequency spectrum. The scanning filter output is connected to a stylus that makes a trace upon a loop of electrically sensitive paper. Recording paper and magnetic tape loops are moved in a fixed relation so that successive scanning cycles are recorded side by side, thus building up a frequency-time-intensity picture.

If the words pictured in Fig. 1 were repeated at different times by the same speaker, the repetitions would look much alike unless a deliberate attempt were made to change the voice. If the words were spoken by different individuals they would also have a similar appearance, although the pattern shapes would vary with individual characteristics in much the same way that handwriting varies among individuals. To the extent that words sound alike they will also look alike in visible speech form, and to the extent that they sound differently they will look differently. That is, of course, to be expected if the portrayal is accurate.

The similarity in word patterns for various individuals is illustrated by Fig. 2. Here are shown six enunciations of the word "speech" by as many speakers. As indicated, the upper three are female voices and the lower three male. The brief descriptions at the right are only intended to give an impression of the wide range of voice quality represented and should not be interpreted as meaning that all speakers with a "Throaty Voice" or a "Scotch Irish Accent" or an "English Accent" would produce patterns that are just like those so identified. The important point in this illustration is the evidence that characteristic differences in pronunciation do not overshadow the similarities that enable one to recognize particular words. Such similarities illustrate the possibilities of these patterns for visual hearing.

In the studies of sound patterns as applied to the problems of the deaf, the objective thus far has been to determine whether the patterns are sufficiently intelligible for practical use. This has involved a careful study of the patterns of different sounds and sound combinations with respect to both their similarities and their differences. Two methods of investigation were utilized—the first by training individuals to read patterns and following their progress, and the second by what are called "visual discrimination tests" that require no training.

The training group formed for the purpose of learning to read the patterns originally included six girls with normal hearing. This group was assigned to the work on a part-time basis during the summer of 1943. Teachers were selected with experience in the fields of phonetics and education of the severely deafened, but they started the instruction with no previous knowledge of the speech patterns. In addition to this handicap, the first months of training were based entirely upon the sound spectrograph patterns which require several minutes for completion.

A method of instantaneous translation was needed badly, but equipment of this type was not available for class use until the fall of 1944. The first direct translator utilizing a new form of moving screen cathode-ray tube was entirely too large and complicated for any but experimental instruction use. There has since been constructed a much smaller translator, approximately the size of a portable typewriter, with the speech patterns displayed on a moving drum of phosphorescent material. While this more recent unit approaches a practical size, it is still very much in the experimental stage and far from a finished design.

There is also under experimental development a large screen translator of the same general design as the small unit but using a belt of phosphorescent material in place of the drum. In all three of these translators, transient speech patterns are formed by tracing on a moving screen the frequency distribution of speech energy as determined by a bank of fixed band pass filters. The frequency scale used for the speech patterns is linear, although patterns with other scales, including the logarithmic type, have been produced.

One objective in the development of the small translator is to provide a type of unit that might ultimately be associated with telephones in such a way as to permit the very deaf to carry on telephone conversations by seeing, rather than hearing, the speech signals.

Due, at least in large part, to the exploratory nature of the training program and the time required to develop adequate equipment, the ability of the experimental class to read visible speech increased at what would be considered a slow rate for learning lip reading, shorthand, or foreign languages. However, the learning rate improved considerably as the training methods and translators were improved. Recently a congenitally deaf engineer, who depends

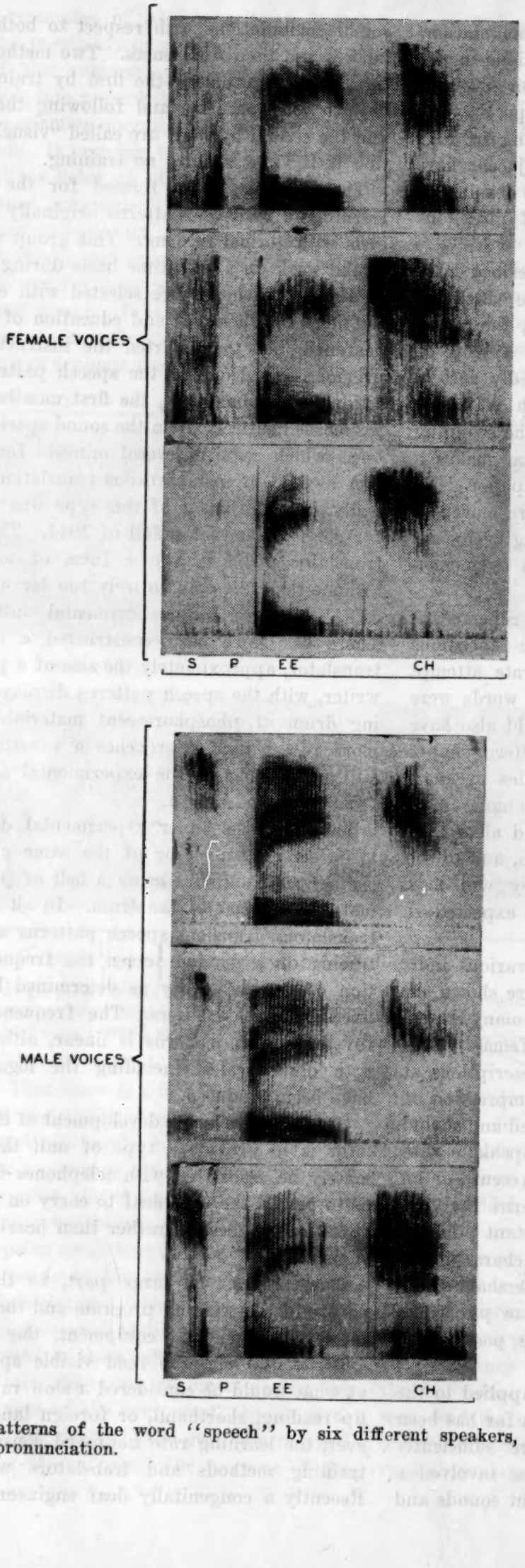

FIG. 2. Patterns of the word "speech" by six different speakers, including male and female voices and a wide range of pronunciation.

entirely upon lip reading, has been added to the class. His learning rate for visible speech has so far compared favorably with that for lip reading. During his training he has been tested regularly on his ability to read word patterns in the visible speech form and by reading lips. Although adept at lip reading, and the lip reading tests were carried on under exceptionally favorable conditions, his score on reading visible speech has stayed well above that for reading lips. Incidentally, his is probably the first case in which a person with substantially no hearing has been enabled to talk over an ordinary telephone circuit without the aid of a human "interpreter."

Thus far the results of the experimental training encourage confidence that these speech patterns may provide a practical form of directly translated visible speech, but much more training experience is needed for complete confirmation.

A second way to determine the legibility of word patterns, by means of so-called "visual discrimination tests," was initially devised to get around a difficulty. It had been assumed at the start of the visual hearing project that the trainees would, after a period of training, be able to say whether one pattern presentation was better than another, and how the many variables that appear in the translator design should be treated. But this assumption proved to be mistaken. After training with one form of pattern there was a tendency to dislike others. It soon became obvious that an unbiased evaluation method was necessary as a guide to development.

The visual discrimination tests produced to meet this situation depend upon an assumption that any language, aural or visible, is made up of many patterns; and that the relative merit of different languages or of different representations of a single language depends upon the ease with which patterns that make up equivalent vocabularies may be identified. In the visible speech case, one test method is to select words that in certain respects look alike, and arrange them in what are called "similarity series." Examples are "man, ran, van, tan," etc. The words are spoken in groups of three, such as "van-tan-tan" or "van-van-tan." An observer of the patterns produced by these words is simply asked to check whether the middle pattern is more nearly like the first or last in a group. It is not required that the observer have any knowledge of the meaning of the patterns. Ratings are in terms of the percentage of correct pattern identifications, taking into account the fact that 50 per cent. accuracy represents pure guesswork. The figure so derived is called the "discrimination index." Poor patterns result in a low DI, or if the translator fails to show certain sounds clearly, the DI for word groups containing these sounds will be relatively low. Figures of this kind permit a quantitative appraisal of the performance of different translators.

Any one who considers carefully the relation between aural and visual perception is likely to question the need for using a three-dimensional form of pattern for visible speech. The ear hears two-dimensionally in frequency and intensity. The time dimension is supplied by the memory. Why not then show only a frequency-intensity speech pattern and make similar use of the visual memory? The question is a perfectly valid one and has received considerable thought during the investigation under discussion. In fact, an experimental study of two-dimensional patterns is being carried on simultaneously with the three-dimensional studies. At the present time it is confined to visual discrimination tests of various two-dimensional displays. Earlier, one girl studied a particular form of pattern for a few months, but when the discrimination test methods were developed this training was discontinued in order to concentrate the available effort upon the more fundamental aspects of two-dimensional display.

Both the limited training and the visual discrimination tests made so far seem to indicate that it will be more difficult to read the two-dimensional patterns than it is to read the three-dimensional type. Three-dimensional speech patterns are analogous to print moving from right to left on a telegraph tape, while two-dimensional patterns are analogous to seeing this moving print through a narrow slit, only as wide as the lines that form the letters. No doubt we could learn to read print moving past such a narrow slit, but it would rather obviously be more difficult than unrestricted reading because we normally perceive whole words rather than bits of letters. It may well be that this manner of reading is a result of the requirement that the eye be focused upon the print in order to obtain a satisfactory memory impression. Although the focusing requires visual effort, large pattern areas may be recorded in a single "exposure" so that the effort is not excessive. But to record patterns a bit at a time, or two-dimensionally, by the visual process would require almost continual concentration and should therefore exact more effort for the same accomplishment.

It is possible then that even though the eye should in theory be able to understand two-dimensional patterns of speech it may be inefficient for this purpose.

In addition to the problem of understanding others, deaf and severely deafened persons are faced with the problem of controlling their own speech. Making sounds without ears to hear them is somewhat like drawing pictures with no eyes to see the results. When the hearing is largely absent in a child, it is necessary to teach speech without the normal control exercised by the hearing. Even in cases

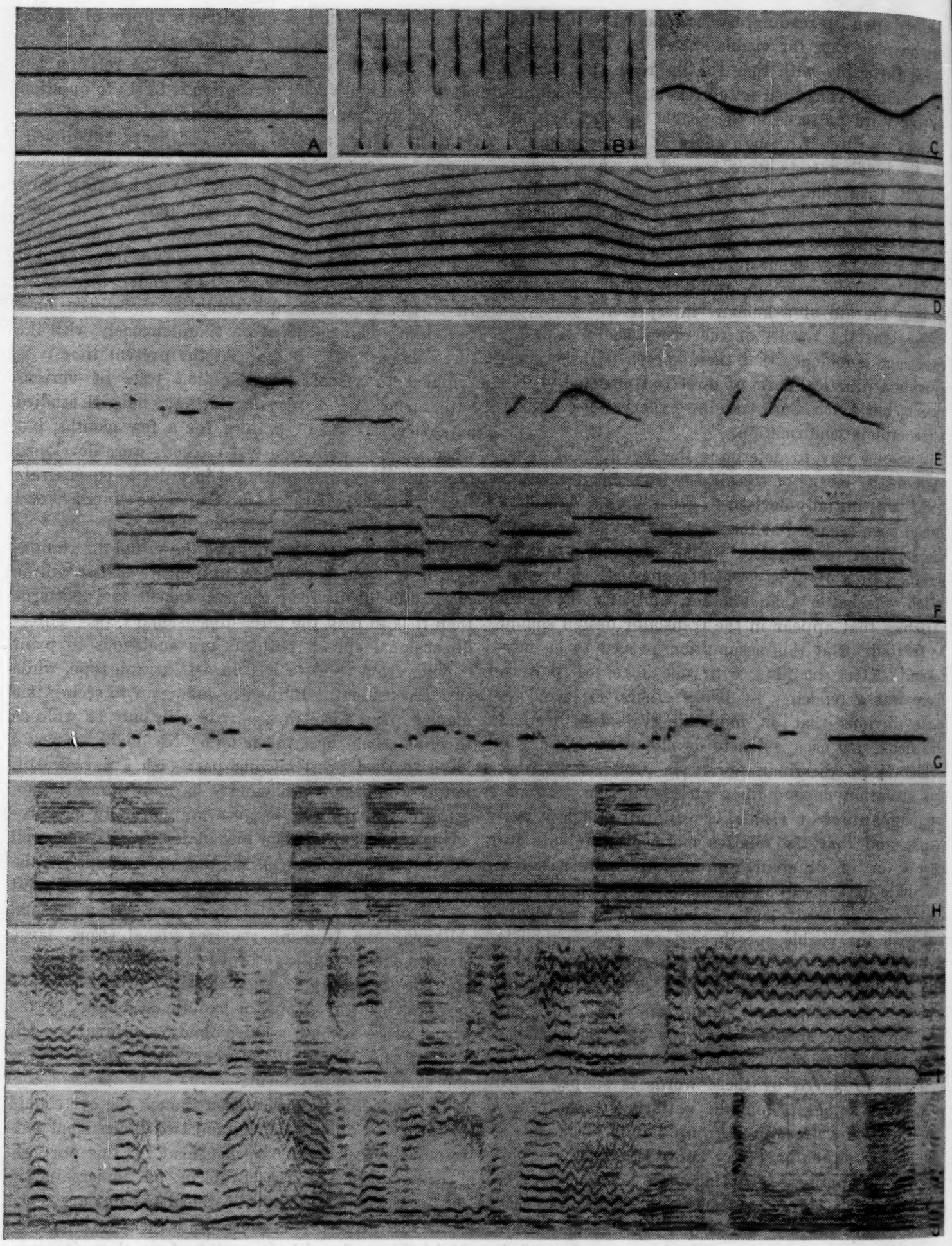

FIG. 3. Sound patterns of:

A—Three steady tones
B—Hammer clicks
C—Wobbled tone
D—Siren
E—Man whistling
F—Oboe solo
G—Ocarina solo
H—Ship's bell ("5 bells")
I—Tenor and orchestra
J—Soprano and baritone

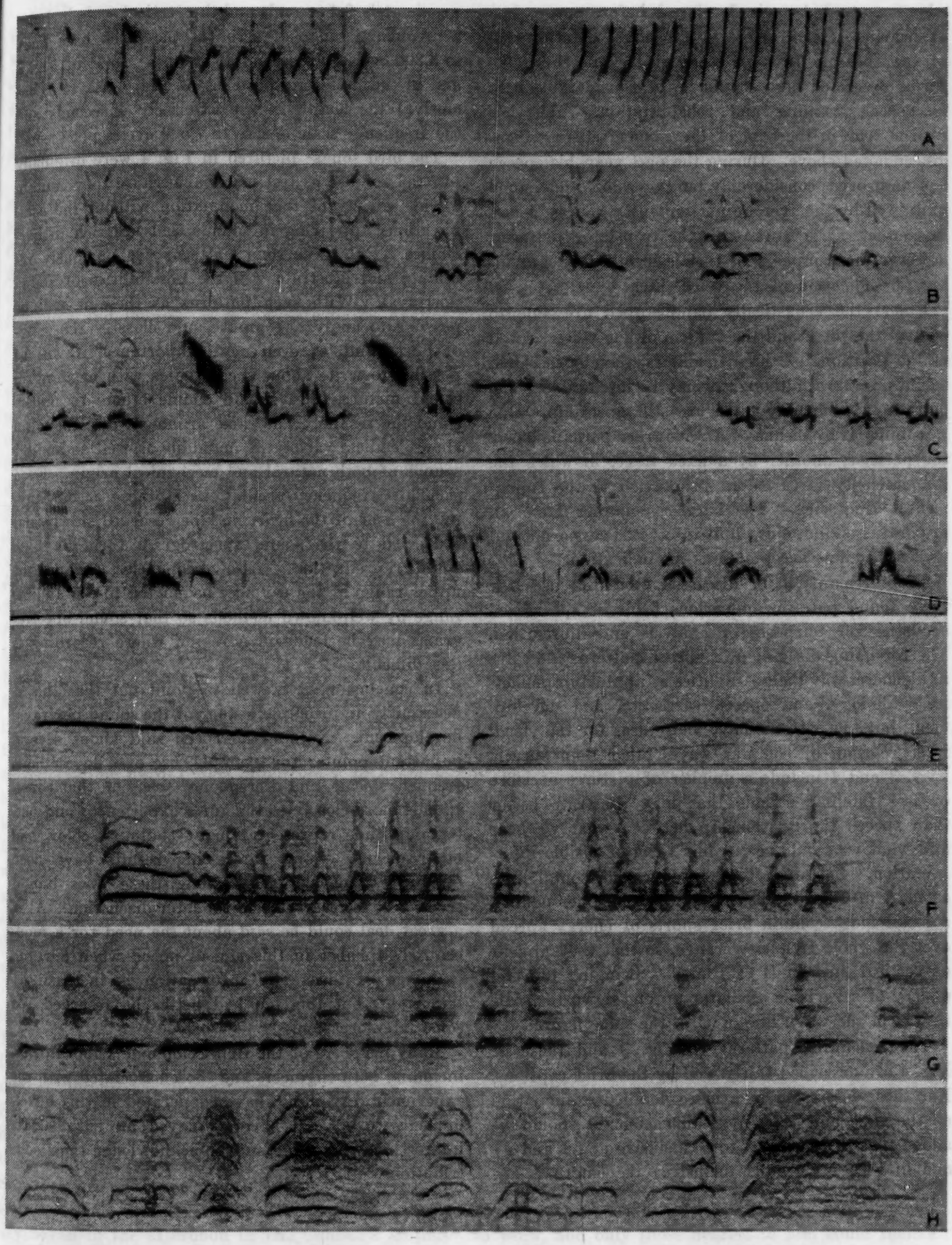

FIG. 4. Sound patterns of:

A—Cardinal
B—Robin
C—Mocking bird
D—Brown thrasher
E—Screech owl
F—Large dog barking
G—Small dog yapping
H—Baby crying

where a vocabulary is developed before severe loss of hearing sets in, there is a gradual deterioration of the speech. In both cases visible speech in the forms described here should be of considerable help in speech training and rehabilitation. This has proven true in the case of the congenitally deaf engineer noted above. During the past year, his speech has improved considerably and can be understood quite well by the average person with whom he comes in contact. His work with the translator patterns, however, has emphasized the desirability of providing an indication of the voice pitch.

Unless the acoustically handicapped are able to control the pitch and the volume of the voice as well as the positions of the articulators, their speech will sound unnatural although it may be intelligible. The best ways to display pitch are still uncertain. One possibility is by means of a wave trace perhaps below the pattern; another by a fixed trace, in which the line intensity is varied in proportion to the fundamental frequency. The latter is simpler from an apparatus standpoint, but in a first experimental use seemed less acceptable as an indication.

There remains to be discussed, potential uses for these sound patterns in various fields of specialized acoustics for purposes of analysis and illustration. The foregoing discussion of speech patterns indicates in a general way the possibilities as applied to phonetics, philology, and speech correction and development, but the patterns have many uses for the visual interpretation of complex waves other than speech. Figs. 3 and 4 include a number of pictures of more or less familiar sounds that may illustrate better than speech the relationship between what we hear and what we would see in this form of visible interpretation. Sustained tones produce horizontal lines as in A of Fig. 3. The clicks of a hammer against a metal block contain brief spurts of energy spread over the whole frequency range, so that they appear as vertical lines in B of Fig. 3. Swinging the frequency of a variable oscillator up and down the scale results in the wavy line of C in the same figure.

The remaining patterns of Fig. 3 and those of Fig. 4 are described fairly well by the brief captions. For those interested in a more detailed examination of the time and frequency dimensions it should be added that in Fig. 3 (A to G inclusive and I and J) and in Fig. 4 (E to H inclusive) the length is approximately 9.4 seconds and the vertical scale includes a frequency range of zero (at the black base line) to 3,200 cycles per second at the top. In H of Fig. 3 and in the first four patterns of Fig. 4 (A to D inclusive) the length is approximately 4 seconds and the frequency scale is zero to 7,500 cycles per second.

The bird songs[1] pictured in Fig. 4 were originally selected for use as test material because they contain a wide variety of tone modulation without the complications appearing in sounds that are rich in harmonics. But these song patterns are obviously revealing and illustrate well the possibilities of sound portrayal. With such patterns as these it will be possible to analyze, compare, and classify the songs of birds, and, of even more importance, it will be possible to write about such studies with meaningful sound pictures that should enable others to understand the results. The same argument applies to an almost endless variety of inaudible as well as audible sounds of both natural and mechanical origin. Even such low frequency oscillations as those accompanying the beat of the heart may be recorded slowly and converted to the sound spectrogram form by high speed reproduction. Also frequencies beyond the upper range of the ear may be shifted to the audible range by well-known methods so that sound spectrograms may be made in a region where recording is less difficult.

In conclusion, it is well to point out that this is necessarily an incomplete story of the sound portrayal development. Nothing has been said about several important points: for example, use of a logarithmic frequency scale, and a frequency selection that corresponds more closely to the aural experience; and better amplitude representation by contours, color, and other means. Some interesting results have been obtained in developments along these lines but it seems best to reserve them for later discussion. Also, a great deal could be said about the need for a modernized alphabet in this age of speed when a rapid exchange of ideas and information is increasingly important, but this too had better be reserved for some later occasion.

Many members of the Bell Telephone Laboratories, including both engineers and those associated with the experimental training, have cooperated in this development work. All have displayed an enthusiastic interest and it is a pleasure to acknowledge their contributions.

[1] These sound spectrograms were made from the Cornell Bird Song Records (Albert R. Brand Bird Song Foundation, Laboratory of Ornithology, Cornell University).

OBITUARY

WALTER BRADFORD CANNON

1871–1945

A FEW months before his death Dr. Cannon's last book was published. It is called "The Way of an Investigator" and is an autobiography in the best sense, since it presents those aspects of his life which in long view he felt most useful to others. This book,

with other records such as the material in the small volume published in 1932 to commemorate his twenty-five years as a professor at Harvard, will provide details as to his many accomplishments and distinctions. Here it seems more appropriate to write of the man as so many of us knew him.

All that Dr. Cannon entered was vivified by his capacity for personal interest. Though critical of his own work he was integrated so deeply in all he did as to make impersonality, detachment of view, difficult for him. He worked for himself and through others with the intentness of an artist. His complete frankness and honesty were his safeguards against mistaken bias.

Dr. Cannon was so engrossed with his physiological problems and kept his own hands so deep in experimental work, that it became an unending wonder to many of us to realize how extensively he was active outside his research. For years he was the great effective liberal in the Harvard Medical School. He never refused service upon committee after committee. At the same time he never lost touch with general university activities in Cambridge. Resuscitation commissions of national scope, the American Medical Association, the wide-flung interests of the National Academy, the American Association for the Advancement of Science, the problems of cooperative aid to Russia, China, Spain and South America were but a few of his involvements. His participation in all these outside issues was no rubber-stamp contribution. I knew how great a service he rendered beyond the university, but until I had opportunity to examine his files of correspondence and notes, had no conception of the detail and systematic care each outside task received. There was, for example, almost a wheelbarrowful of letters, requests for grants in aid, analyses of policy, all annotated in his own hand and all expressing his careful attention to the affairs of the National Foundation for Infantile Paralysis, in which he was a member of the guiding committee.

When a great figure in our life is gone, we resort to artifices of varying type to describe the loss. There can be no one who requires certification of Dr. Cannon's place in the history of medical advance, through listing the distinctions that came to him. He valued these recognitions of service and originality, for he was a very human man. He was deeply touched by the celebration at the Harvard Medical School which commemorated his twenty-five years as a professor in the university. The exercises on this day began in the afternoon in Dr. Cannon's amphitheatre, Building C, where he had lectured to so many students. All that was said through afternoon and evening came from the hearts of distinguished pupils and co-workers.

Dr. Cannon liked people, all sorts of people, listened to what they said, was on their level instinctively, and was sustained by a sense of humor that never left him. It was part of a youthfulness of spirit which expressed itself so constantly in all his outlook upon life.

I remember so well my first intimate encounter with him, in Baltimore in 1916. He asked me to breakfast at the Maryland Club, and reinforced the breakfast with an offer to join his staff in Boston and so become committed to physiology in earnest. I remember how his enjoyment of the situation grew from his own experience, how he said, "Years ago the only thing in the world I wanted was a chance to work in physiology, and then Harvard University not only gave me the opportunity but actually paid me for it!" I came to the Harvard laboratory in 1916, after Dr. Cannon had finished his classical work upon the mechanical factors in digestion, the sea into which he and Dr. Bowditch had sailed while he was a medical student. To many, Dr. Cannon's reputation will rest chiefly upon these fortunate early experiments. But to all who knew his habit of mind, they merely pulled the trigger. Whether again he ever brought down such big game was in the fortune of the chase. He followed the leads set by his imagination, and out of early and characteristically acute observations upon the effects of emotional disturbances in cats under x-ray examination of intestinal movements, grew the large body of research upon the emergency function of the sympathetico-adrenal mechanism, and finally the search for the eventual chemical mediators of neuromuscular phenomena.

He had been fortunate in the possession of so rugged a physique (in all my early years with Dr. Cannon he loved to describe himself as "hearty!") as to be able to work his way through Harvard College and the Medical School, gaining a distinguished record in each case. He graduated in medicine in 1900, having published two classical papers upon gastro-intestinal movements as observed for the first time with the x-rays. But, characteristically, the young Dr. Cannon closed his medical school career with additional assets—an earned balance of seven hundred dollars, a wife and a trip to Europe for a bit of mountaineering!

Fifteen years ago, Dr. Cannon learned he was afflicted by one of the inexorable lymphomatous diseases, all so poorly understood and all so disastrous. His illness inevitably ate a little into his humor and his irrepressible good spirits, but not into his will to work, and only those nearest to him could realize a vestige of change.

Dr. Cannon was an artist in classical physiological technique. One has only to glance at the tracings which illustrate his articles to realize how capable he was with his hands. He used all sorts of tools

easily and effectively from early years, but always upon his own occasions. He was a beautiful surgical operator, a fact so evident in the nerve ablation experiments which distinguished his later career. He was better than a good sculptor. He rejoiced in this dexterity and relied upon it. Yet I remember how characteristically he spoke at lunch in the Brigham Hospital years ago. At the beginning of the Ford era he purchased a car, the first in a long series. These Fords had character. On cranking, they responded to a definite formula or balked aggressively. Each car was an object of affectionate regard by the entire Cannon family, but Dr. Cannon never learned the anatomy and physiology of the Ford as known to millions throughout the land. He had too many vivid interests to burden his consciousness with the idiosyncrasies of even the most worthy Ford, remarking characteristically that he relied upon the "Vis medicatrix Fordi!" to keep the current old faithful in motion!

It is our habit to seek for influences which start men of great accomplishments upon their careers. Usually such efforts result in highly artificial syntheses inappropriate to the man involved. At his twenty-fifth anniversary dinner, Dr. Cannon described himself as the grandson of Ludwig and the son of Bowditch. But no teachers really influenced him. He had his own "self-starter" which never failed to stir and stir in his agile brain. His spirits rose and fell as he saw himself progressing or baffled in the current research. What Dr. Cannon accomplished was all his own. No one else had the ideas, no one else labored painstakingly over pupils, giving ideas and counsel without thought for self. What he published came wholly from his brain. His other contribution, the researches of pupils scattered all over the world, will speak Dr. Cannon's obituary as he would wish. Questions being answered, never an end of questions! In the study of living processes something is always beyond the horizon. Indeed, our progress is devoted to pushing back the horizon so that as we gain knowledge we are never satisfied with our gains. Dr. Cannon enjoyed this struggle. He judged contemporaries and pupils by their ability to ask good questions. Amongst his files I have come upon one large folder labelled "Questions." Here, upon varied bits of paper but always in his legible hand, are scores of questions noted as they came to him, and usually without comment.

Peptic ulcer from simultaneous stimulation vagus and sympathetic?

Factors affecting the growth of hair?

Milk secretion as affected by fright, rats (hissing sound)?

Effect of secreted adrenalin on bronchioles in dog?

Unilateral effect of convulsants?

Catnip in relation to sex? Spayed cats?

Dr. Cannon was fortunate in that much of his life was spent in the Harvard Medical School while it was under the administrative direction of Dr. Edsall. These two men saw eye to eye in their desire to extend productive scholarship through every department of the school. They worked and died together, leaving an example of accomplishment their pupils will be hard set to equal.

CECIL K. DRINKER

DEATHS AND MEMORIALS

DR. JOHN CAMPBELL MERRIAM, from 1920 to 1938 president of the Carnegie Institution of Washington, died on October 30 at the age of seventy-six years.

THE death, at the age of seventy-six years, is announced of Robert Hagelstein, honorary curator of Myxomycetes at the New York Botanical Garden.

AT the annual Robert Kennedy Duncan Memorial Luncheon on October 29 the Robert Kennedy Duncan Club of Mellon Institute conferred honorary membership on Dr. Rufus Henry Fitzgerald, chancellor of the University of Pittsburgh. The club is in honor of the late Robert Kennedy Duncan, the originator of the industrial fellowship system; it is the center of the social and professional life in the institution.

SCIENTIFIC EVENTS

NUCLEAR PHYSICS AND CHEMISTRY AT HARVARD UNIVERSITY

RESEARCH in nuclear physics, the branch of science which helped develop the atomic bomb, will be made broader at Harvard University during the next five years. The Harvard Corporation has appropriated the sum of $425,000 for use of a committee on nuclear physics and chemistry during this period. Dean Paul H. Buck, provost of the university, will head the committee, members of which have not yet been announced.

Two other developments emphasize the university's interest in the atom and its possibilities in times of peace. The Harvard cyclotron, which did service with the Manhattan project of bomb development at Los Alamos, is to be returned to Cambridge for additional atom-smashing labors.

Three new associate professors of physics, all

trained in nuclear research or theory, have been elected to the Harvard faculty. One is Dr. Robert Rathbun Wilson, formerly assistant professor of physics at Princeton University, who helped to evolve the atomic bomb. Others are Dr. Julian Seymour Schwinger, formerly assistant professor of physics at Purdue University, and Dr. Edward Mills Purcell, formerly tutor in Harvard's department of physics.

The Harvard cyclotron or atom-smasher, was constructed at the Gordon McKay Engineering Laboratory in 1938 to aid in the study of phenomena involved in disintegration of atomic nuclei. It was designed to produce atom-smashing projectiles of at least 8,000,000-volt energies. It was one of the mechanical pioneers in the study of what takes place when atoms are disintegrated.

Return of the cyclotron from war service, which reached an apex with the first use of atomic bombs over Japan, will be celebrated through the necessary construction of a new building in which it is to be placed. Dr. Wilson, who directed the Division of Research in Experimental Physics at Los Alamos, supervised the dismantling of the cyclotron in Cambridge and its re-assembly in New Mexico.

The new committee on nuclear physics and chemistry, headed by Dean Buck, will be representative of allied fields of scientific research. As reported in SCIENCE, the sum of $425,000 which it has been authorized to spend may be used for buildings, equipment or salaries. Within these financial bounds, there is no limitation on the allotment of funds in any one year for the next five years.

THE RESEARCH CORPORATION OF NEW YORK

THE Research Corporation of New York, a nonprofit organization devoted to advancing research and technology by use of revenues from inventions assigned to it by public-spirited inventors during a period of five years, will make grants for research and teaching to educational institutions amounting to the sum of $2,500,000. Preference in making these grants will be given, other factors being equal, to smaller institutions and those of more limited financial resources for research.

Dr. Joseph W. Barker, acting president of the corporation, has returned from service as special assistant to the Secretary of the Navy to his work with the corporation and with Columbia University. One hundred to two hundred grants of $2,500 to $5,000 will be made each year in order that students will be enabled to undertake at universities and colleges research of peace-time importance in pure science, especially in chemistry, physics, mathematics and engineering.

The first grants will be made by a special committee of members of industrial and university laboratories. The committee is composed of Acting President Barker, dean of engineering at Columbia University; Dr. Thomas H. Chilton, director of engineering for du Pont de Nemours and Company; Dr. William D. Coolidge, x-ray consultant for the General Electric Company; Timothy E. Shea, manufacturing engineer of the Western Electric Company; Dr. Lloyd P. Smith, associate research director of the Radio Corporation of America; Colonel Stafford L. Warren, professor of medicine at the University of Rochester; and Dr. Robert R. Williams, inventor of the synthesis of vitamin B_1 and coordinator of research of the Research Corporation.

Grants will be made to the institutions at which the investigators work and teach. The funds allotted will be available for the purchase of needed equipment and for employment of assistants either as fellows or otherwise. Awards will be based primarily upon demonstrated ability.

The Research Corporation was begun in 1912 with the gift, through Dr. F. G. Cottrell, of patent rights on electrical precipitation, which is used for removing dust, fume and mists from industrial gases and from the atmosphere. From revenues derived from these and other patents it has made grants of $1,279,637 in past years to fifty-two institutions. In recent years the Research Corporation has served universities by administering inventions that may arise in their laboratories.

Applications should be addressed to Dr. Robert R. Williams, Research Corporation, 405 Lexington Avenue, New York 17, N. Y.

FREEDOM FOR SCIENTIFIC WORK

THE following resolution has been passed by the Southwestern Section of the Society for Experimental Biology and Medicine:

WHEREAS, there is now much discussion regarding Federal subsidy in support of scientific endeavor, in order to assure the continuance of the benefits of scientific effort, and

WHEREAS, the many reports, published discussions, and other comments relating to this important matter do not fully emphasize assurance of desired and continued freedom for scientific workers, now be it

Resolved, by the Southwestern Section of the Society for Experimental Biology and Medicine that appropriate protagonists for Federal support of scientific work be informed of the section's wish, in company with responsible scientists throughout the nation, to have clear assurance of freedom of scientific endeavor, under any form of Federal subsidy, support, or encouragement, with the understanding that such freedom extend not only to scientific studies and scientific undertakings themselves,

but also to the reporting and discussion of results derived therefrom, and be it further

Resolved, that the section express its concern lest any interference with the necessary freedom of scientific work and the reporting of data therefrom may result in the development of a scientific orthodoxy, which would be detrimental to the ideals of science and democracy and, to the further development of our civilization.

This resolution after discussion was carried unanimously.

CHAUNCEY D. LEAKE, *Chairman*,
DONALD SLAUGHTER, *Secretary*,
SOUTHWESTERN SECTION

NEWS FROM ABROAD

DR. FRANS VERDOORN, editor of *Chronica Botanica* and botanical adviser to the Board for the Netherlands Indies, writes that according to reports received from Java and Singapore, the scientific institutions in the Buitenzorg area (West Java) are relatively in good condition. The classic collections in the Herbarium, as well as the grounds of the famous Botanic Gardens at Buitenzorg, have not been damaged to any considerable extent (it also seems that herbarium material has not been transferred to Japan). The rich library of the Department of Economic Affairs and most of the experiment station buildings are also intact. The following may be quoted from a letter from Dr. C. G. G. J. van Steenis, the well-known authority on Malaysian botany, just received in the U. S. A.:

I lost altogether one year's work, but worked harder than in any other period . . . finished several papers, and am almost ready with my cyclopaedia of botanical collectors, and book on Malaysian Plant Life. . . . Was released as a prisoner of war, August 11, 1942, again in jail, December 14, 1942 to April 13, 1943, worked again to August 13, 1945. Now again interned. . . . The biologists Dr. W. K. Huitema, Ir. P. N. Hackenberg, Dr. J. H. G. Ferman, Dr. M. P. Both, Ir. C. van der Giessen, and P. van der Groot have died. Of many others, especially Dr. M. A. Donk, Dr. P. J. Eyma and T. H. van den Honert, not yet any news. Dr. O. Posthumus, H. C. D. de Wit and my wife still working. Hope to be released soon. . . .

Dr. Rudolf Allers, professor of psychology at the Catholic University of America, writes:

Your readers may be interested to hear that I received a letter from Professor F. J. J. Buytendijk, M.D., head of the laboratory of physiology, Rijksuniversitet, Groningen, telling me that he has returned to his work after half a year of concentration camp and two years of underground activity. He reports that his whole library has been destroyed. He would appreciate enormously whatever he would get in way of reprints and books.

Professor J. Murray Luck, of Stanford University, writes:

Professor Jean Roche, of the Biochemical Laboratory, Faculty of Medicine and Pharmacy of the University of Marseilles, stayed in Marseilles during the occupation. The laboratory welcomed biochemists of various countries unable to work under German control and gave to them the possibility of continuing their work. This was initiated at the time the south of France was not under German occupation. He has been the editor of "*Travaux des Membres de la Société de Chimie biologique*," part of "*Bulletin de la Société de Chimie biologique*," which were edited in Marseilles in order to escape German control and to permit the acceptance of papers which would be free of any political or racial considerations. The publication of the Bulletin was continued even when the south of France was occupied and four volumes have been issued constituting parts of volumes 23 to 26. During this period his work on the chemistry of proteins, chiefly on respiratory pigments and on serum proteins, has been progressing. He has been working particularly on the myoglobins, protein solubility, and was directing research on the chemical mechanisms of ossification (quantitative studies on the calcification of bone slices in vitro; role of ascorbic acid in bone formation). The chief work has been devoted to the phosphatases and the alkaline phosphatases of kidney and intestine have been crystallized. Professor Roche will be very grateful to American biochemists for reprints of papers in the above fields and for the receipt of reviews in these subjects.

About 30 biochemists were working in Professor Roche's laboratory at the time of the liberation. A few books and *The Biochemical Journal* have been obtained from England but the shortage of books, periodicals, reprints or original publication, and general reviews of American origin is very severe.

News received by *Chronica Botanica* reads:

According to word received from our associate Dr. W. Robijns, director of the "Jardin botanique de l'État" of Brussels, the collections are all safe (it has been reported elsewhere that part of the gardens have been destroyed). Dr. Robijns continues: "Unfortunately Dr. R. Mosseray, assistant at the 'Jardin botanique de l'État' and officer in the Belgian Army, was killed in May, 1940. His death was a real loss for our Institute.—I am glad to say that, during the occupation, our scientific activity has not only been continued, but even extended.—The '*Bulletin du Jardin botanique de l'État*' was issued regularly, but only once a year. We made and started to execute a plan for a Flora of the Belgian Congo, that will comprise about 20 volumes for the whole of the Spermatophytes. The manuscript of Vol. I is nearly completed. On the other hand, I started the preparation of a Flora of the Spermatophytes of the National Albert Park-Kivu region (Belgian Congo), which is finished about half way. You may see that we have not lost our time during the occupation, and that we kept up our minds and our hope in final victory, by steadily preparing for the future!"

Dr. Zacarias de Jesús, of the University of the

Philippines, wrote on October 2 to Professor James E. Ackert, professor of zoology at Kansas State College, as follows:

I have not been able to write to you since I last visited you in July, 1941. During more than three long years of continuous nightmare while the Japs had this country in their murderous grip I remained in the laboratory conducting my researches. The other parasitologists here did the same and we were not bothered most of the time.

During the battle for the liberation of Manila, Dr. Candido M. Africa was one of those massacred by the Japs. All our libraries and museums here were completely burnt. I lost all my records of the three years of laboratory work and my collection of reprints, monographs, bulletins and circulars from abroad from fires in my home and office.

We are now starting all over again in the University of the Philippines and in the research laboratories of the Department of Agriculture. The laboratory equipment and supplies were all lost from fires. Whatever instruments and supplies we are now using are loaned to us by the U. S. Army laboratory units. However, rehabilitation materials are forthcoming and we will be able to rebuild and put up again our laboratories.

Kindly send me reprints which can be spared for our reference use here. We are now about four years behind in parasitology literature.

Dr. de Jesús' present address is in care of the Bureau of Animal Industry, Pandacan, Manila, P. I.

SCIENTIFIC NOTES AND NEWS

DR. PAUL J. FLORY, of the Goodyear Tire and Rubber Company, has been awarded by the Ohio State University the Joseph Sullivant Medal in recognition of his work in the field of high polymers. The medal is given once in every five years to a graduate of the university or to a faculty member.

IN honor of the sixtieth birthday of Dr. Niels Bohr thirty-five Danish firms have established an endowment fund of $175,000.

MAJOR HAROLD MACY, professor of dairy bacteriology at the University of Minnesota, has been named Chevalier of the Legion of Honor by the Government of France with the following citation: "An eminent bacteriologist, who during the course of the war, never ceased to show in a most affectionate manner his friendship for France. Prior to June, 1944, in London, he was entrusted with the duties of head of the Medical Mission for Civil Affairs at SHAEF, and in collaboration with French officers, he contributed an effort the results of which were felt as soon as the landing took place. In London, then in Paris, he maintained keen interest in the assistance which was being given to France, and on several occasions through his own personal intervention brought about considerable help from the Allied and American Armies to the French civilian population."

THE Baly Medal of the Royal College of Physicians, London, has been awarded to Professor Aug. Krogh, of the Zoophysiological Laboratory at Copenhagen. Dr. Krogh was awarded the Nobel prize in physiology and medicine in 1920.

PROFESSOR LEONARD BAIRSTOW, F.R.S., Zaharoff professor of aviation at the University of London, has been awarded the gold medal of the Royal Aeronautical Society and honorary fellowship in the society in recognition of his long service to aeronautics.

DR. JOSEPH H. MOORE, director of the Lick Observatory, Mt. Hamilton, of the University of California, will retire from administrative work on December 1. He will devote full time to his work as astronomer.

DR. GEORGE GAYLORD SIMPSON, curator of fossil mammals and birds in the American Museum of Natural History, and Dr. Edwin H. Colbert, curator of fossil reptiles, amphibians and fishes, have been appointed, respectively, professor of vertebrate paleontology in the department of zoology of Columbia University and professor of vertebrate paleontology in the department of geology.

DR. ELMO N. STEVENSON, who has been professor of science education at Oregon State College since 1940, has resigned to accept the presidency of the Southern Oregon College of Education at Ashland, dividing his time between the school of science and the school of education.

DR. SIDNEY H. CAMERON, associate professor of subtropical horticulture and associate plant physiologist in the Agricultural Experiment Station of the University of California, has been appointed head of the division of horticulture of the College of Agriculture.

DR. HOBART M. SMITH, formerly of the Laboratory of Biology of the University of Rochester, during the absence of Professor Edward H. Taylor, has been appointed for the autumn semester assistant professor in zoology and assistant curator in herpetology in the Museum of Natural History of the University of Kansas.

CLYDE W. TOMBAUGH, a member of Lowell Observatory and of the Arizona State College at Flagstaff, has been appointed visiting assistant professor of astronomy at the University of California at Los Angeles for the term beginning October 26.

DR. W. D. WILKINSON, associate professor of geology, has resumed his work at Oregon State College following his recent discharge from the Army. Holding the rank of captain, he was the chief of libraries of the Army Map Service, Corps of Engineers, following a tour of foreign duty in the Galapagos Islands and Panama.

DR. HORACE WINCHELL has been appointed instructor in mineralogy in the department of geology of Yale University.

DR. MORGAN HARRIS has been appointed instructor in zoology at the University of California at Berkeley.

THE retirement is announced of Dr. Lyman J. Briggs, director of the National Bureau of Standards. Dr. Edward U. Condon, of the Westinghouse Research Laboratories, has been nominated to succeed him.

ARTHUR WILFRED ASHBY has been appointed director of the British Institute for Research in Agricultural Economics of the University of Oxford. The appointment is for seven years from January 1, 1946.

AT the University of London, J. Z. Young, F.R.S., has been appointed to the university chair of anatomy tenable at University College, Oxford. He is a fellow of Magdalen College, Oxford, university demonstrator in zoology, and since 1940 has been a member of the Nerve Injuries Committee of the Medical Research Council. Professor F. G. Young, professor at St. Thomas's Hospital Medical School, has been appointed to the university chair of biochemistry tenable at University College.

DR. HERBERT F. PRYTHERCH, marine biologist, in charge of the U. S. Fishery Laboratory at Beaufort, N. C., has completed his war assignment as coordinator of Fisheries for the Chesapeake Bay–North Carolina region. As confidential observer for the U. S. Navy he has been awarded a special certificate from the Eastern Sea Frontier "in recognition of his patriotic services." Facilities for marine research are again available at the Beaufort Laboratory for investigators and graduate students from outside institutions.

M./SGT. ARNOLD C. MASON, specialist in groundwater, associate geologist of the Illinois Geological Survey, on military leave, in charge of water supply in an engineer combat group, has been transferred to teach at the Delta Base Education Center, Marseille.

DR. CONRAD B. LINK, assistant professor of horticulture at Pennsylvania State College, has been appointed horticulturist at the Brooklyn Botanic Garden.

DR. ERMA A. SMITH, associate professor of physiology at the Iowa State College, has become physician in the Health Service at Michigan State College, East Lansing. She took up her work there on October 8.

DR. E. CLIFFORD WILLIAMS, vice-president and director of research of the Shell Development Company, General Mills, Inc., and General Aniline and Film Corporation, a director of the United States Industrial Alcohol Company, has been appointed vice-president in charge of research of the Schenley Distillers Corporation. He will assume the responsibility of coordinating and directing all the scientific research and development activities of the company. Dr. A. J. Liebmann, who has been president of the Schenley Research Institute, will devote his time to research within the new organization.

DR. WILLIAM E. HANFORD, head of the central research laboratory of the General Aniline and Film Corporation at Easton, Pa., has been appointed director of research.

MAJOR GEORGE W. HUNTER, III, SN.C., has returned to duty at the Army Medical School, Washington, D. C., from the Philippines and Borneo. While there he served as executive officer of the Commission on Schistosomiasis of the Army Epidemiological Board.

GEORGE T. MOTOCK, metallurgical engineer with the Metalloy Corporation, Minneapolis, has returned from a three months' stay in Europe where he served as scientific consultant, investigating technical developments in German industry for the War Department.

THE Royal Geographical Society has appointed Lieutenant-Colonel L. P. Kirwan secretary of the society, in succession to the late A. R. Hinks, F.R.S. Before the war he was engaged on archeological and anthropological work, much of it in the field in Egypt, the Sudan, Arabia and England.

PROFESSOR G. I. FINCH, F.R.S., left England by air on October 10 to carry the greetings of the Royal Society on behalf of the men of science of Great Britain to their colleagues in Belgium and Holland. The purpose of his visit is to renew and re-establish scientific contacts and to see what help can be given by British science towards the rehabilitation of science and scientific education in these two countries. In Belgium Professor Finch will be the guest of the Académie Royale des Sciences, des Lettres et des Beaux-Arts in Brussels, and in Holland he will be the guest of the Koninklijke Akademie van Wetenschappen.

AT a meeting of the Kappa Chapter of Sigma Xi at Columbia University on October 31 a lecture entitled "Recent Advances in Radar," illustrated by motion pictures, was given by Dr. L. A. Dubridge,

director of the Radiation Laboratory of the National Research Committee. Dr. I. I. Rabi, of the department of physics, officiated as chairman.

DR. WILLIAM H. ADOLPH, acting professor of biochemistry and nutrition at Cornell University, addressed on October 17 the University of Cincinnati Section of the Society of the Sigma Xi. He spoke on "Chemistry in China."

DR. ALFRED BLALOCK, professor of surgery and director of surgery at the Johns Hopkins University and surgeon-in-chief, the Johns Hopkins Hospital, will deliver the second Harvey Society Lecture of the current series at the New York Academy of Medicine on November 15. The title of the lecture will be "Physiopathology and Surgical Treatment of Congenital Cardiovascular Defects."

A SERIES of three lectures will be given by Dr. Torbjörn Oskar Caspersson, director of the department for cell research of the Medical Nobel Institute, Stockholm, under the Edward K. Dunham Lectureship for the promotion of the medical sciences at the Harvard Medical School, on November 13, 14 and 16. The title of the series is "Cytochemical Studies of Nucleic Acid and Protein Metabolism."

THE first meeting of the Society for the Study of Blood was held at the New York Academy of Medicine on the evening of November 8. The scientific program included papers by Dr. John T. Edsall, associate professor of biological chemistry, and by Dr. Louis K. Diamond, assistant professor of pediatrics, both of the Harvard Medical School; by Dr. Randolph West, associate professor of medicine, and by Dr. Erwin Chargaff, assistant professor of biochemistry, both of the College of Physicians and Surgeons, Columbia University.

THE American Fern Society has received as a bequest from Miss Amey Lillibridge, of Providence, R. I., the sum of $1,000 in addition to her library and herbarium of ferns.

THE fifty-second annual meeting and twenty-seventh colloquium of the American Mathematical Society will be held at the Museum of Science and Industry, Chicago, on Friday and Saturday, November 23 and 24, in conjunction with meetings of the Mathematical Association of America. The sessions of the society will begin on Friday at 9:30 and will continue through Saturday afternoon. The sessions of the association will be held on Saturday evening and Sunday morning. The colloquium will consist of four lectures on "Length and Area" by Professor Tibor Radó, of the Ohio State University, on Friday at 9:30 A.M. and 2 P.M. and on Saturday at 10 A.M. and 2 P.M. The nineteenth Josiah Willard Gibbs Lecture will be delivered by Professor J. C. Slater, of the Massachusetts Institute of Technology, on Friday evening at 7:30 P.M. The title of this address is "Physics and the Wave Equation." The annual business meeting and election of officers will be held on Saturday morning at 9:30 A.M. At 11 A.M., by invitation of the Committee to Select Hour Speakers for Western Sectional Meetings, Professor S. M. Ulam, of the University of Southern California, will deliver an address entitled "On the Stability of Solutions of Functional Equations."

THE centenary of the Imperial College of Science and Technology was celebrated in London in October. The college was constituted by Royal Charter in 1907; it is a federation of the Royal College of Science, the Royal School of Mines and the City and Guilds College. They are related to earlier institutions, the earliest of all being the Royal College of Chemistry, which was founded in 1845.

THE *British Medical Journal* reports that the Government of India established on September 1 a Department of Agriculture, a Department of Health and a Department of Education, in place of the existing single Department of Education, Health and Lands. Sir Sardar Jogendra Singh, minister in charge of the conjoint department in the Viceroy's Executive Council, will for the time being take charge of all three departments.

ERRATUM: In the review by Professor Noble P. Sherwood of Dr. Landsteiner's book entitled "Specificity of Serological Reactions" which appeared in SCIENCE, 102: 360–361, 1945, the word "neutralize," from before the word "strychnine" in the last sentence of the first paragraph discussing Chapter 5, was accidentally omitted. The sentence should read, "In connection with this, the author discusses the attempts and failures to produce antibodies to neutralize strychnine and the success achieved in producing antibodies to thyroxine."

SPECIAL ARTICLES

A CHEMICAL-MECHANICAL THEORY OF MUSCULAR CONTRACTION[1]

THE obvious problem of muscular contraction is to determine the mechanism by which the energy developed as adenosine triphosphate in carbohydrate

[1] The Bureau of Medicine and Surgery of the Navy does not necessarily endorse views or opinions expressed in this paper.

metabolism is transferred to myosin and converted into mechanical energy. The contributions of Engelhardt and co-workers[2] need not be detailed here except to acknowledge that their finding that the transfer of energy of adenosine triphosphate is apparently associated with the relaxation of the myosin has provided the stimulus for a theory to be presented at this time.

This theory does not account for all the phenomena involved in muscle contraction, but it does provide a chemical-mechanical basis of that contraction which should be subject to experimental proof or disproof. It is unique in that it employs the only known system of energy transfer involving side chains of amino acids known to be present in the myosin molecule.

The theory may be stated briefly as follows: The contraction phase of myosin activity is visualized as a result of the condensation of the sulfhydryl and the phosphorylated hydroxyamino acid side-chains of the myosin molecule with the consequent release of inorganic phosphate and formation of a thio-ether linkage. Such reactions could bring about a considerable shortening of the myosin molecule if the sulfhydryl and hydroxyamino acid side-chains were strategically placed in the polypeptide chain. The relaxation of myosin would involve the phosphorylytic cleavage of the thio-ether linkage by adenosine triphosphate to produce free sulfhydryl and phosphorylated hydroxyamino acid side-chains.

The evidence for such reactions is, at best, of an indirect nature and rests largely upon observations made on the mechanism of the conversion of homocysteine to cysteine by liver tissue of rats. It has been found that the thio-ether containing amino acid cystathionine is cleaved to cysteine and probably a phosphorylated hydroxyamino acid by a phosphorylytic mechanism involving adenosine triphosphate.[3] As in the adenosine triphosphate activity of muscle only the terminal phosphate is utilized. The cleavage of cystathionine would correspond to the relaxation phase of myosin activity.

The contraction phase, or the condensation of sulfhydryl and phosphorylated hydroxyamino acid side-chains, finds an analogy in the condensation of homocysteine with serine to bring about the formation of cysteine with the probable intermediate formation of cystathionine.[4] A further analysis of this reaction[5] has revealed that in the presence of homocysteine the phosphate of phosphoserine is transferred to adenosine diphosphate with the formation of adenosine triphosphate. The condensation of homocysteine with the serine must take place, for some cysteine is formed and a considerable portion of the homocysteine disappears, coincident with the formation of adenosine triphosphate. It has been suggested above that the condensation of sulfhydryl with phosphorylated hydroxyamino acid side-chains of the myosin molecule would result in the release of inorganic phosphate. The condensation of homocysteine with phosphoserine, on the other hand, brings about the formation of a phosphate grouping of high energy. The apparent contradiction in the theory proposed for myosin activity and the observed behavior of the homocysteine-phosphoserine system is resolved when it is considered that the energy normally residing in the sulfhydryl-phosphorylated hydroxyamino acid system would be utilized in the mechanical process of shortening the myosin molecule or lost as heat in isometric contraction.

The reactions suggested as being involved in the myosin molecules may be presented schematically as in Fig. 1.

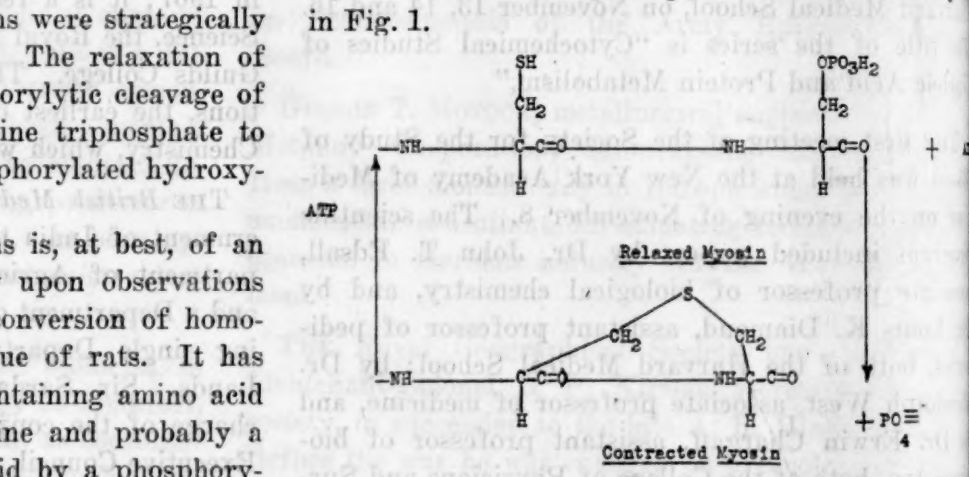

FIG. 1.

The concept of transfer of phosphate of high energy by a protein molecule by the sulfhydryl-phosphorylated hydroxyamino acid side-chains system may be of importance to an understanding of enzyme action in other phosphate transfer systems for, if the enzyme molecule is constructed so that little energy is involved in the condensation phase, the reaction between the protein and such compounds as adenosine triphosphate and creatine phosphate should be reversible.

The theory as presented is consistent with the evidence for the participation of sulfhydryl groups in the adenosine triphosphatase activity of myosin but a discussion of that evidence need not be made at this time. An interpretation of the x-ray data and the temporal relationships of muscular activity as related to the theory will be postponed, inasmuch as the

[2] W. A. Engelhardt and M. N. Ljubimova, *Nature*, 144: 668, 1939. W. A. Engelhardt, "Advances in Contemporary Biology," 14 (1941), as translated in *Yale Jour. Biol. Med.*, 15: 21, 1942.

[3] F. Binkley, *Jour. Biol. Chem.*, 155: 39, 1944.

[4] F. Binkley and V. du Vigneaud, *Jour. Biol. Chem.*, 144: 507, 1942.

[5] F. Binkley, unpublished observations.

appears to be no *a priori* inconsistency and the predictions which may be made are, in the most part, subject to experimental attack.

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THEORY AND NOMENCLATURE OF THE Hr BLOOD FACTORS[1]

THE hypothesis proposed by Fisher[2] that there are three different varieties of antisera capable of agglutinating Rh-negative blood, corresponding to the three varieties of anti-Rh sera[3,4] appears to be gaining ground. Therefore, there is need for a clear statement of the status of the Hr factors and an acceptable method of designating the sera and factors postulated under the theory, such as has been devised for the Rh blood factors.[5,6]

Since the three varieties of antisera reacting with Rh-positive bloods are collectively known as Rh antisera, the three varieties postulated by Fisher as acting on Rh-negative bloods may be designated collectively as Hr antisera. The great majority, if not all, Hr antisera found until recently have given reactions resembling those described by Levine and Javert[7] for the original Hr antiserum in that the sera regularly agglutinated bloods not reacting with anti-Rh′ serum. That Levine obtained only 30 per cent. positive reactions with his Hr antiserum, while Race and Taylor[8] obtained 80 per cent. positive reactions with their Hr antiserum (designated by them St after the first two letters of the name of the patient from whom the serum was obtained) has been explained by Wiener[9] as due to the low potency of Levine's serum so that only bloods homozygous for the Hr factor reacted with it. Sera of this specificity will henceforth be designated standard anti-Hr sera, just as Rh antisera giving reactions parallel with the original anti-rhesus serum of Landsteiner and Wiener are known as standard anti-Rh sera.

According to the theory of Race and Taylor, which is now firmly established, standard anti-Hr sera react with the agglutinogens determined by genes Rh_2, Rh'', Rh_0 and rh, but not with the agglutinogens determined by genes, Rh_1, Rh', Rh_y and Rh_z. Therefore, standard anti-Hr serum and anti-Rh′ serum are related serologically and genetically like anti-M and anti-N.[9,10] To indicate this, standard anti-Hr serum may also be designated simply as anti-Hr′. Since the other two Hr antisera postulated by Fisher are related to anti-Rh″ and anti-Rh_0, in the same way that anti-Hr′ (or standard anti-Hr) is related to anti-Rh′, these two antisera may now be designated as anti-Hr″ and anti-Hr_0, respectively.

The reactions of the three sorts of anti-Hr sera with the agglutinogens determined by the six standard Rh allelic genes of Wiener[3,4] and the genes Rh_y and Rh_z of Race and Taylor[11,12] can now be summarized as shown in Table 1.

TABLE 1
THE RH SERIES OF ALLELIC GENES*

Designation of genes†				Reactions with Rh antisera			Reactions with Hr antisera		
1 Preferred	2	3	4	Rh′	Rh″	Rh$_0$ (standard Rh)	Hr′ (standard Hr)	Hr″	(Hr$_0$)
rh	*rh*	*rh*	*rh*	−	−	−	+	+	(+)
Rh_0	Rh^0	Rh_0	Rh^0	−	−	+	+	+	(−)
Rh′	*Rh′*	*Rh′*	*Rh′*	+	−	−	−	+	(+)
Rh_1	Rh^1	Rh_0'	$Rh^{0'}$	+	−	+	−	+	(−)
Rh″	*Rh″*	*Rh″*	*Rh″*	−	+	−	+	−	(+)
Rh_2	Rh^2	Rh_0''	$Rh^{0''}$	−	+	+	+	−	(−)
(Rh_y)	(Rh^y)	(Rh''')	($Rh^{'''}$)	(+)	(+)	(−)	(−)	(−)	(+)
Rh_z	Rh^z	Rh_{12} or Rh_0'''	$Rh^{0'''}$	+	+	+	−	−	(−)

* Does not include the intermediate genes. Reactions, genes and antisera enclosed in parentheses have been predicted but not yet encountered.

† These do not represent different nomenclatures but merely variations of a single method of designating the genes.

It will be seen that in Table 1, four slightly different methods of designating the genes of the Rh allelic series are given. The reason for this is that certain minor objections have been raised to the first and simplest method of designating the genes—the one preferred by the present writer. According to the convention adopted by American geneticists, genes belonging to the same allelic series are assigned the same basic symbol and are differentiated by superscripts, while subscripts are reserved for genes at different loci having similar effects. Since very few allelic series are known for man in contrast to the situation in Drosophila, there is hardly any danger of confusion from the use of subscripts instead of superscripts in man, but if a change in nomenclature becomes essential in order to satisfy the geneticists, the second set of designations could be adopted. With regard to the third and fourth sets of designations, these are preferred by many workers because the names of the genes more clearly indicate with which Rh antisera the corresponding agglutinogens react. There is no

[1] Aided by a grant from the United Hospital Fund of New York City.

[2] Cited after R. R. Race, *Nature*, 153: 771, 1944.

[3] A. S. Wiener, SCIENCE, 98: 182, 1943.

[4] A. S. Wiener, *Proc. Soc. Exp. Biol. and Med.*, 54: 316, 1943.

[5] A. S. Wiener, SCIENCE, 99: 532, 1944.

[6] A. S. Wiener, *Jour. Amer. Med. Asn.*, 127: 294, 1945.

[7] Cited by P. Levine, *Jour. Ped.*, 23: 656, 1943.

[8] R. R. Race and G. L. Taylor, *Nature*, 152: 300, 1943.

[9] A. S. Wiener, I. Davidsohn and E. L. Potter, *Jour. Exp. Med.*, 81: 63, 1945.

[10] P. Levine, SCIENCE, 102: 1, 1945.

[11] R. R. Race and G. L. Taylor, *Nature*, 153: 560, 1944.

[12] J. Murray, R. R. Race and G. L. Taylor, *Nature*, 155: 112, 1945.

doubt that these alternative methods of designating the genes are helpful to individuals learning the Rh genetic and serologic theory for the first time, but for general use the first and second sets of symbols are preferred because they are simpler. It is obviously a disadvantage to use a cumbersome symbol such as Rh_o' or $Rh^{o\prime}$ as the name for the most common Rh type and gene. To individuals accustomed to learning abbreviations like t. i. d., t. p. r., etc., an abbreviation like Rh_1 should not be too difficult to master. The advantages of a streamlined nomenclature as far as facility in referring to the Rh types verbally or in writing should certainly be obvious, and the extra effort entailed in learning the designations under column 1 or 2 in the table will soon be repaid.

The recent work on the various Hr antisera does not in any way affect the nomenclature of the Rh genes. The reason for this is that there is a reciprocal relationship betwen the Rh and Hr antisera, so that if the reactions of an agglutinogen with the Rh antisera are known, the reactions with the three Hr antisera are obvious on inspection. Since the purpose of a name is to identify and not to give a complete description, it is neither necessary nor desirable to change the designations of the Rh genes in order to include the reactions with the Hr antisera.

The properties in the red cells reacting with the three varieties of Rh antisera, anti-Rh_o, anti-Rh′ and anti-Rh″, are known as the Rh factors, Rh_o, Rh′ and Rh″, respectively.[5, 6] Similarly, one may postulate the existence of three Hr factors corresponding to the three varieties of Hr antisera, namely Hr_o and Hr′ and Hr″. Each of these six blood factors, considered individually, is inherited as a simple Mendelian dominant. For example, factor Rh′ may be considered to be inherited by a pair of allelic genes, $\overline{Rh'}$ and $\overline{rh'}$. (The bar is placed over designations of the collective genes $\overline{Rh'}$ and $\overline{rh'}$ in order to distinguish them from the gene Rh' of the series of allelic genes listed in Table 1. The collective gene $\overline{Rh'}$ includes the genes Rh', Rh_1, Rh_y and Rh_z of Table 1, while collective gene $\overline{rh'}$ includes genes rh, Rh_o, Rh_2 and Rh''.) Similarly, factor $\overline{\text{Hr}'}$ may be considered to be inherited by means of a pair of allelic genes, $\overline{Hr'}$ and $\overline{hr'}$. It is obvious on inspection that gene $\overline{Rh'}$ is identical with gene $\overline{hr'}$, and gene $\overline{rh'}$ is identical with gene $\overline{Hr'}$. In fact, if tests are made only with sera anti-Rh′ and anti-Hr′, three types are distinguished, $\overline{\text{Rh}'}$, $\overline{\text{Rh}'\text{Hr}'}$, and $\overline{\text{Hr}'}$, inherited by a pair of allelic genes $\overline{Rh'}$ and $\overline{Hr'}$, so that, as has already been mentioned, the situation is identical with that which exists for the three M-N types.

From the foregoing, it is evident that the percentage of positive reactions that a particular Hr antiserum would be expected to give in a population can readily be calculated if the percentage of positive reactions that the corresponding Rh antiserum gives is known. Thus,

$$\text{Hr}+ = 1 - [1 - \sqrt{(\text{Rh}-)}]^2.$$

For example, it is known that Rh′ antisera give 70 per cent. positive reactions on blood samples from white individuals. Therefore, the expected frequency of positive reactions of standard Hr antiserum (anti-Hr′) on white individuals equals $1 - [1 - \sqrt{(0.30)}]^2 = 1 - (1 - 0.55)^2 = 1 - 0.20 = 80$ per cent., approximately. Similarly, since anti-Rh″ sera give 30 per cent. positive reactions on white individuals, it would be expected that anti-Hr″ sera should give approximately 97 per cent. positive reactions. Applying these computations also to anti-Rh_o and anti-Hr_o sera, and to the various populations for which data concerning the distribution of the Rh blood types have been compiled, Table 2 was constructed. In Table 3 are summarized the results of the present writer's investigations on the distribution of the Hr factor, using two different Hr antisera with parallel specificities. It will be seen that the findings confirm the conclusion that the antisera used in these studies were anti-Hr′ sera, or correspond to what we have defined as standard Hr antiserum.

TABLE 2

RELATIONSHIP BETWEEN RH AND HR ANTISERA

Racial group	Observed* percentages of positive reactions with Rh antisera			Expected percentages of positive reactions with Hr antisera		
	Rh′	Rh″	Rh_o (standard)	Hr′ (standard)	Hr″	Hr
Whites	70	30	85	80	97	63
Negroes	28	27	90	97.7	97.5	54
American Indians; Chinese; Japanese	85 to 95	40 to 60	99 to 100	43 to 63	86 to 95	0 to 20
Asiatic Indians ...	85	18	93	63	99.1	45

* A. S. Wiener, E. B. Sonn and R. B. Belkin, *Proc. Soc. Exp. Biol. and Med.*, 54: 238, 1943; A. S. Wiener, J. P. Zepeda, E. B. Sonn, and H. R. Polivka, *Jour. Exp. Med.*, 81: 559, 1945.

TABLE 3

DISTRIBUTION OF THE HR FACTOR IN VARIOUS RACES

Population	Investigators	Number of persons tested	Percentage of positive reactions	
			Observed	Expected
Whites	Wiener, Davidsohn and Potter*	239	72.0	80.0
	Wiener†	350	80.0	80.0
Negroes	Wiener, Davidsohn and Potter*	49	98.0	97.7
Mexican Indians	Wiener, Zepeda, Sonn and Polivka‡	98	55.8	53.8

† Unpublished data.
‡ *Jour. Exp. Med.*, 81: 559, 1945.
* *Jour. Exp. Med.*, 81: 63, 1945.

Until recently no antisera had been encountered giving reactions corresponding to anti-Hr″ or anti-Hr_0. Just a few months ago, Mourant[13] reported that he had obtained an Hr antiserum from an Rh-positive mother of an erythroblastotic infant that gives only 3 per cent. negative reactions. Moreover, all the negatively reacting bloods proved to be homozygous for the gene Rh_2, so there seems hardly any doubt concerning the correctness of Mourant's conclusion that the serum in question corresponds to anti-Hr″. On the other hand, the present writer is convinced that Race *et al.'s*[14] contention that Levine's Hr antiserum corresponds to anti-Hr_0 is incorrect. The contention of Race *et al.* is based on the statement[15] that a "potent" anti-Hr serum of Levine's gave negative reactions consistently with bloods of type Rh_1Rh_2 and positive reactions with 60 per cent. of type Rh_1 bloods. Wiener's earlier interpretation that Levine's bizarre results (such as his incorrect statement[16] that in cases of hemolytic disease due to the Hr factor, the mother is Rh positive and the infant Rh negative) were due to the use of weak anti-Hr sera is supported by the statement that "almost all colored individuals tested possessed the Hr factor," which corresponds to the expectations for anti-Hr′ serum and not for anti-Hr_0 serum (*cf.* Table 2). The more consistent results obtained by Levine on Negro bloods are readily understandable because most are homozygous for the Hr′ factor and so their bloods would be expected to react strongly even with weaker Hr′ antisera. On the other hand, the high percentage of persons heterozygous for the Hr′ factor among whites explains Levine's erratic findings in tests on such individuals.

In conclusion, a brief discussion of the medicolegal application of the Rh and Hr blood tests in cases of disputed paternity may be of interest. For the past six months, the present writer has been applying the Hr test (Hr′) in such cases, alongside of the tests for the blood groups, subgroups of A, M-N types and Rh types, and the results in the first 23 cases are given in Table 4. It will be seen that in one case the man was shown not to be the father by the Hr test, and in this case he would not have been excluded had the examination been limited to the grouping, M-N and Rh tests. A man falsely accused of paternity now has better than a 50 per cent. chance of proving his innocence, if tests for the A-B-O blood groups, subgroups of A, M-N types, Rh types and standard Hr factor are performed. When and if the factors Hr″ and Hr_0 become available, the chances of exclusion will be further increased. Under the genetic theory of the Rh and Hr factors, exclusions of paternity would be based on the following two laws: (1) Factors Rh′, Rh″, Rh_0, Hr′, Hr″ and Hr_0 can not appear in the blood of a child unless present in the blood of one or both parents; (2) parents with blood lacking a particular

TABLE 4

RESULTS OF TESTS IN CASES OF DISPUTED PATERNITY

Case	Putative Father	Mother	Children	Interpretation
1.	(a)† $A_1MRh_1Rh_2Hr^+$ (b) $OMNRh_1Rh_2Hr^+$	$OMNRh_1Hr^+$	(a) $OMRh_1Rh_2Hr^+$ ♀ (b) $OMRh_1Hr^-$ ♀ (c) $A_1MRh_1Hr^-$ ♀	Putative father (b) excluded by A–B–O tests for child (c). No conclusion possible for the other two children
2.	$A_2MNRh_2Hr^+$	$A_2NRh_1Hr^+$	$BMNRh_1Rh_2Hr^+$ ♂	Exclusion by A–B–O tests.
3.	$A_2BMRh_1Hr^+$	$OMNRh_1Rh_2Hr^+$	$A_2MNRh_1Hr^-$ ♂	No exclusion
4.‡	$A_1MNRh_1Hr^-$	$BMNRh_1Rh_2Hr^-$	$A_1BMNRh_1Rh_2Hr^-$ ♀	" "
5.	$OMNRh_1Hr^-$	$OMNRh_1Hr^-$	$OMRh_1Hr^-$ ♀	" "
6.	$A_1BMRh_1Hr^-$	$ONRh_1Hr^-$	$BMNRh_1Hr^-$ ♂	" "
7.	$OMNRh^-Hr^+$	$OMRh_1Hr^-$	a) $OMRh_1Hr^+$ ♂ b) $OMNRh_1Hr^+$ ♀	" "
8.*	$A_1MNRh_2Hr^+$	$OMNRh_1Rh_2Hr^+$	$A_1MNRh_2Hr^+$ ♀	" "
9.	$OMRh_1Hr^+$	$OMNRh_1Rh_2Hr^+$	$OMRh_1Rh_2Hr^+$ ♂	" "
10.*	$BMNRh_0Hr^+$	$BMRh_0Hr^+$	$BMRh_0Hr^+$ ♀	" "
11.	$A_1MRh_1Rh_2Hr^+$	$BMNRh^-Hr^+$	$A_1MRh_1Hr^+$ ♂	" "
12.	$BMRh^-Hr^+$	$A_1BNRh_1Hr^-$	$BMNRh_1Hr^+$ ♀	" "
13.	$A_2MRh^-Hr^+$	$A_1NRh_1Hr^-$	$A_1MNRh_1Rh_2Hr^+$ ♀	Exclusion by Rh tests
14.	$OMRh_1Hr^-$	$A_1BNRh_0Hr^+$	$BMNRh_1Hr^+$ ♀	No exclusion
15.	$A_1MRh_2Hr^+$	$A_1NRh_1Hr^+$	a) $A_1MNRh_2Hr^+$ ♀ b) $A_1MNRh_2Hr^+$ ♀	" "
16.	$OMNRh_1Hr^+$	$OMNRh_1Hr^+$	$OMNRh_1Hr^+$ ♀	" "
17.	$BMNRh_1Hr^-$	$A_1NRh_1Hr^+$	$BNRh_1Hr^-$ ♂	" "
18.*	$OMRh_0Hr^+$	$BNRh_2Hr^+$	$A_2MNRh_1Hr^+$ ♂	Double exclusion by A–B–O and Rh tests
19.	$A_1MNRh_1Hr^-$	$BMNRh_1Hr^-$	$OMRh_1Hr^-$ ♂	No exclusion
20.*	$OMRh_0Hr^+$	$ONRh_1Rh_2Hr^+$	$OMNRh_2Hr^+$ ♂	" "
21.	$A_1MNRh_1Hr^+$	$A_1MNRh_1Kh_2Hr^+$	$A_1MNRh_1Rh_2Hr^+$ ♀	" "
22.	$A_1MNRh_1Hr^+$	$OMRh_1Rh_2Hr^+$	$OMRh_2Hr^+$ ♀	" "
23.	$A_1MRh_1Hr^-$	$OMNRh_1Hr^+$	$OMNRh_0Hr^+$ ♂	Exclusion by Hr-Rh tests.

* Negroes.
† Husband.
‡ Mother and child in case 4 both carry the rare gene Rh_2.

[13] E. Mourant, *Nature*, 155: 544, 1945.
[14] R. R. Race, M. N. McFarlane, D. F. Cappell and R A. Fisher, *Nature*, 155: 543, 1945.
[15] R. K. Waller and P. Levine, SCIENCE, 100: 453, 1944.
[16] P. Levine, *Human Fertility*, 9: 65, 1944.

Rh factor can not have children with blood lacking the corresponding Hr factor; and parents lacking any of the Hr factors can not have children lacking the corresponding Rh factors.

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EFFECT OF DDT, SULPHUR AND LETHANE DUSTS ON GERMINATION OF SUGAR-BEET AND ONION POLLENS

GERMINATION tests were made with sugar-beet pollen collected from portions of sugar-beet seed fields that had been given a single application (20 pounds per acre) of a dust containing 5 per cent. DDT and 95 per cent. pyrophyllite in comparison with similar tests with pollen from undusted portions of the field. Sugar-beet pollen throughout the entire blooming period had shown very poor germinations, making it difficult to obtain exact quantitative data. However, the results of numerous tests were appraised as showing approximately the same germination ratings for pollen from dusted plots as for pollen from undusted plots. The germination tests with sugar-beet pollen were made on an agar medium containing 40 per cent. sucrose, found to be the optimum sucrose concentration to use. Companion tests with onion pollen showed excellent germinations regardless of whether the flowers had been exposed to DDT dust or not. An agar medium containing sucrose at concentrations ranging from 15 to 32 per cent. was used. The indications are that germination of these two kinds of pollen was not adversely affected by the DDT dust. No observations were made on the effects of DDT upon the insects that frequent the sugar-beet and onion flowers. Obviously, DDT should not be used in onion-seed fields after the flowers begin to open because of its known lethal effect upon the insects that pollinate onion flowers.

Sulphur dust as a single application of superfine sulphur at the rate of 20 to 30 pounds per acre, shortly after the blooming period of sugar beets commenced, appeared in the preliminary tests to slow up or inhibit germination of sugar-beet pollen. However, if care was taken not to get sulphur particles on the agar medium along with the pollen, the rate of germination and energy of germination were not greatly affected as a result of the field having been dusted with sulphur. When sugar-beet fields are dusted heavily with sulphur, some of the dust falls upon the anthers and stigmas, so that direct inhibitory effects of sulphur comparable to those observed on artificial media may be a factor in nature.

Lethane B 71 (an organic thiocyanate dust containing beta, beta-dithiocyanodiethyl ether) used at the rate of 30 to 40 pounds per acre on onion fields during the blooming period did not adversely affect germination of onion pollen. During the first few tests agar plates receiving a considerable amount of Lethane dust together with the onion pollen showed no germinating pollen grains. To avoid these direct effects of the dust on the agar medium, both broken and intact anthers from onion flowers were removed individually and placed on the agar medium. Pollen from broken anthers germinated abundantly whether removed 2, 3 or 5 hours after exposure to the fumes of the Lethane dust. The germination energy of pollen from plants dusted with Lethane appeared to be slightly higher than that of pollen from control plants. The material for the pollen studies with onion was supplied by the Division of Horticulture of the New Mexico Agricultural Experiment Station.

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THE DEVELOPMENT OF LITOMOSOIDES CARINII FILARIID PARASITE OF THE COTTON RAT IN THE TROPICAL RAT MITE[1, 2]

VARIOUS blood-sucking arthropods have been explored as possible vectors of the cotton rat (*Sigmodon hispidus litoralis*) filariid, *Litomosoides carinii*. To date, only in the mite, *Liponyssus bacoti*, has development of the filariid been demonstrated.

In mites fed on infected rats, all stages of development have been recovered. The microfilariae grow in length from 69 μ (not including the sheath) to 105–109 μ while there is a rather gradual increase in width from 5.5 μ to 7 μ. At this point in the development there is a sudden expansion in width to 13.2 μ and a typical sausage form with a short sickle-shaped tail is formed. The width increases and individual variations ranging from 15.6 μ to 20.8 μ were found among those larvae between 125 μ and 510 μ in length. From this point on in the development of the worm the width appears to become fixed at 15.6 μ. Those forms which were presumed to be the infective stage reached a length of 800 μ. Further studies are being made on the development of the worm within the mite and its transmission to the cotton rat.

Other ectoparasites of rats that were examined, including fleas, lice and ticks, did not harbor developing filariae. In five species of mosquitoes (*Aedes aegypti, A. taeniorhynchus, A. sollicitans, A. albo-*

[1] This study was made possible through the financial support of the John and Mary R. Markle Foundation.
[2] The authors wish to express their gratitude to the Hegener Research Supply Company of Sarasota, Florida, for the helpful assistance rendered.

pictus and *Mansonia perturbans*) no development of the microfilariae took place and three days after a blood meal all microfilariae appeared to be digested. Similar results were obtained with the bedbug, *Cimex lectularius*. Three species of sandflies (*Culicoides*) showed no interest in feeding on the cotton rats.

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SCIENTIFIC APPARATUS AND LABORATORY METHODS

A RAPID STAINING METHOD FOR RICKETTSIA ORIENTALIS[1]

THE difficulties encountered in staining *Rickettsia orientalis*, the causative agent of Tsutsugamushi disease (scrub typhus or mite-borne typhus fever), in smears from infected yolk sac membranes and animal tissues are well known. In smears stained by Machiavello's method[2] or with 1 per cent. methylene blue the rickettsiae are stained deeply enough to be recognized, but the lack of contrast with the tissue background makes differentiation of the organisms difficult.

Recently Syverton and Thomas[3] reported that preliminary treatment of smears with lipid solvents followed by Giemsa stain gave uniformly satisfactory results in the staining of *R. orientalis*. However, their technique is somewhat more time-consuming than the method, used in this laboratory for the past eight months, described below.

In 1944, Dr. T. J. Kurotchkin[4] of this laboratory used a dilute aqueous solution containing both methylene blue and basic fuchsin to good advantage in staining *Rickettsia prowazeki* and *Rickettsia mooseri*, the causative agents of louse-borne (epidemic) typhus and murine (endemic) typhus respectively. In yolk sac smears thus treated the rickettsiae stained blue while the tissue background assumed a pinkish-purple color.

The present authors found the dilute stain solution to give nearly identical results with smears of *R. orientalis*, providing the smears were first treated with a lipid solvent such as xylol, ether or chloroform, to remove excess fatty substances. Xylol was found to be most convenient to use since it is less volatile and is readily kept in a glass-stoppered dropping bottle.

The method of staining is as follows: Smears of infected yolk sac membranes or other tissues are prepared, air dried and fixed by heat. The slide is flooded with xylol, drained and after drying in a current of air is immersed for five minutes in a distilled water solution containing methylene blue 1:5,000 and basic fuchsin 1:5,000. The preparation is then washed in tap water, dried and examined.

The dilute stain is readily made from 1 per cent. stock solutions of each of the two dyes and should be prepared daily to obtain best results.

SUMMARY

A rapid method for staining *R. orientalis* is described. Smears of infected tissues are defatted and stained in a dilute aqueous solution of methylene blue and basic fuchsin. Smears thus stained show *R. orientalis* as blue organisms on a pinkish-purple background.

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A METHOD OF OPENING VACUUM DESICCATORS

WHEN analytical samples are dried in vacuum desiccators, the covers often "freeze" and it becomes almost impossible to remove them manually, particularly when certain high-vacuum type greases are used. In some cases it has been necessary to resort to the dangerous practise of putting air under pressure into the desiccator, generally with loss of the sample being dried.

A simple and successful method, which is new to us, for opening such desiccators has been used in this laboratory for some months. A single-edged and sharp razor blade, such as the "Gem," which has a metal backing strip, is placed between the edges of the top and body of the desiccator and gently tapped with a small block of wood. The extremely thin wedge thus attained forces the lid off. Even under full vacuum, lids may be removed; thus the method is useful for removing the lids of ordinary desiccators when a vacuum is inadvertently obtained by allowing hot samples to cool therein with the lid on. Thin double-edged blades are not very satisfactory, since they are too flexible for use.

The precaution of wearing goggles should be observed to avoid possibility of injury by a flying particle of glass or steel. Careful cleaning of the ground glass surface before the cover is replaced is necessary to remove particles which might lodge in the grease and cause injury to the surface.

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[2] H. Zinsser and S. Bayne-Jones, "A Textbook of Bacteriology." 8th edition. pp. 654–655. New York: D. Appleton-Century Company, 1939.
[3] J. T. Syverton and L. Thomas, *Proc. Soc. Exp. Biol. and Med.*, 59: 87–89, 1945.
[4] Timothy J. Kurotchkin, personal communication.

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DISCUSSION

SPINDLE TWISTING IN THE GIANT AMOEBA

DURING a comparative study of the nutritional requirements and nuclear structure of *Amoeba proteus* and the giant amoeba, *A. carolinensis*,[1] observations of anaphase in the latter have revealed what appears to be a property of the spindle which has not previously been recognized. The giant amoeba is multinucleate and during mitosis all the nuclei in one individual are in approximately the same stage of division. During anaphase the half spindle regions do not appreciably change in length, but the spindle between the daughter groups of chromosomes elongates as these chromosomes (or early telophase nuclei) move sometimes as far as 62 μ apart. As this elongation progresses, the interzonal spindle undergoes a twisting such as would result in the rotation of the daughter groups of chromosomes in opposite directions. This twisting is easily seen until the chromosomes are up to 45 mμ apart. With further elongation a more complex distortion appears and dissolution of the fibers of the interzonal region occurs.

A single amoeba[2] was found with all its nuclei, 33 in number, at anaphase or early telophase. Of these 4 are at early telophase and the remainder at the anaphase stage. Twelve of the spindles are so elongated, contorted and in such a state of dissolution that they could not be properly resolved. Of the 21 spindles that lend themselves to analysis, one, with chromosomal plates 17 μ apart, shows no twisting of the interzonal region of the spindle (Table 1).

TABLE 1

Distance of daughter groups apart (μ)	Number spindles right	Number spindles left	Number not twisted
13–17	0	0	1 (17 μ)
18–22	9	0	0
23–27	3	0	0
28–32	4	0	0
33–37	1	0	0
38–42	2	0	0
43–47	1 (44 μ)	0	0
Total	20	0	1

The other 20 spindles, the chromosomal groups of which are 19 to 44 μ apart, have their interzonal regions clearly twisted, while the fibers of the half spindle region are straight. The direction of the twist in every one is clockwise or to the apparent right (Fig. 1, ×1660).

These observations, though limited, are of considerable significance. The fact that the spindles consistently twist in one direction indicates that this twisting which accompanies spindle elongation is not

FIG. 1.

a chance phenomenon brought about by cytoplasmic movement or other external factors operating on the spindle. This interpretation is further strengthened by the fact that the spindles are oriented at random in the cell. The constancy in direction of the twisting would result from a property inherent in the spindle apparatus, possibly an uncoiling of spindle elements as elongation proceeds.

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ONE-PARENT PROGENY OF TUBIFICID WORMS

UNDER this title, is a recent article, Purdy[1] has reported the production of young by isolated tubificid worms of the genera *Tubifex* and *Limnodrilus*. This phenomenon was studied by Černosvitov[2] in *Tubifex tubifex* (Müller) and has been further investigated by Gavrilov[3,4] in several other species of oligochaets. Both these authors believe that some form of self-fertilization occurs, although the possibility of parthenogenesis does not appear to be completely excluded. In one case (*Limnodrilus udekemianus* Clap.) spermatophores were found in the spermathecae of isolated individuals, from which Gavrilov concludes that self-fertilization takes place by way of a process of self-copulation. However, in two other species of this genus (*L. hoffmeisteri* Clap. and *L. claperedeianus* Ratzel), as in *T. tubifex* and also in the lumbricid *Eiseniella tetraedra* (Sav.), the spermathecae never contain spermatozoa unless reciprocal copulation has occurred. If the production of uniparental progeny is the result of self-fertilization it must, in these species, be achieved by some other means than self-copulation. Gavrilov, supporting earlier findings of

[1] = *Chaos chaos* of some authors.

[2] Fixed in Carnoy and stained in Haidenhain's Iron-Haematoxylin.

[1] W. C. Purdy, SCIENCE, 102: 182, 1945.

[2] L. Černosvitov, *Biol. Zlb.*, 47: 587–595, 1927.

[3] K. Gavrilov, *Biol. Zlb.*, 51: 199–206, 1931.

[4] K. Gavrilov, *Acta Zool.*, 16: 21–64, 1935.

Gathy, Černosvitov and others, claims that there are the same number of chromosomes on the first and second maturation spindles as during segmentation and that, in this respect, there is no difference between normal and uniparental eggs. The interpretation of this remarkable situation is obscure and the facts themselves require fuller investigation. Against the occurrence of parthenogenesis, Gavrilov believes that he has found evidences of spermatozoa in the uniparental eggs.

Uniparental production of progeny is probably quite general among the Oligochaeta. Gavrilov quotes unpublished observations of Černosvitov on *Enchytraeus albidus* Henle and of Janda on *Eisenia foetida* (Sav.); in both these forms reproduction can occur in the absence of reciprocal copulation. On the other hand, isolated specimens of *Rhynchelmis limosella* Hoffm. showed reduction of the sexual organs and produced at most only a few uniparental eggs which failed to develop beyond the segmentation stages. According to Kobayashi[5] there are as many as ten species of the oriental genus *Pheretima* which frequently or even usually lack male pores. This author was able to demonstrate the production of viable young by individuals of the Japanese-Korean species, *P. hilgendorfi* (Michaelsen), which were without male pores and which had been isolated before reaching sexual maturity. As in the case of the species discussed previously, parthenogenesis is not excluded, but the presence of testes argues in favor of some form of self-fertilization.

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HAMSTER SEXUALLY MATURE AT TWENTY-EIGHT DAYS OF AGE

SHEEHAN and Bruner[1] have summarized our limited knowledge of the care, breeding habits and estrous cycle of the golden hamster (*Cricetus auratus*). Their published data on the development of the hamster pups and on the gain in weight through the sixth week of growth have been substantially corroborated by the writer.

Our records show that the newly born young averaged 1.9 grams instead of 2.23 and 2.49 grams for the females and the males as recorded by Sheehan and Bruner, and our young hamsters did not show a failure to gain weight during the fourth week as they reported.

The females will breed only during the early evening hours. During November copulation began about 7 P.M. (Pacific war time) and during March and April about 7:30. On December 5th a female refused to copulate at 5 P.M., again refused at 6 P.M., and at 7 P.M. copulated repeatedly with all four of the males in the cage. When not in heat the females usually attack the males and occasionally inflict wounds of varying degrees of severity.

The estrous cycle of the hamster recurs every four days. During the morning following an evening when the female was receptive for copulation, a white mass of vaginal fluid containing leucocytes and epithelial cells appears at the orifice of the vagina. Upon application of slight pressure with the finger it can be expressed readily. The evening of the third day following the appearance of the vaginal exudate the female will again be in heat. We found this to be a very simple and satisfactory way of keeping track of the cycles in the different females.

In addition to water, the hamsters were fed daily a standard laboratory pellet for dogs and liberal amounts of fresh bur clover (*Medicago hispida*) of which they were exceedingly fond. What special part, if any, the bur clover had in stimulating early breeding can not be stated by the writer; however, stockmen have long recognized bur clover as being a highly nutritious forage plant.

Hamsters are said to breed at eight to twelve weeks of age.[1] Upon several occasions the writer observed young females from 42 to 45 days of age copulating with mature males. Two of these females, one that copulated on the 42nd day, gave birth to eight young, and the other (45th) contained fourteen fetuses when she was killed on the fourteenth day of gestation.

In order to determine the minimum age at which the female hamster will breed, ten 21-day-old females from two litters were selected on April 25th. Each evening for an hour they were placed in a cage with seven sexually experienced males. They copulated at the following ages in days: 27, 28, 29, 29, 30, 31, 31, 38, 42. The tenth female never copulated during the experiment and was the only one of the ten that did not become pregnant during the two months that the experiment was in progress.

The female that copulated when she was 28 days old gave birth to five young when she was 44 days of age! She successfully raised and weaned all five of them. Another female, the one that copulated on her 31st day, had nine young when she was 47 days old and raised them all. The two next youngest females were 54 and 58 days of age when their litters of four and nine young were born. In these experiments the young were usually born on the sixteenth day of gestation; however, on several occasions young

[5] S. Kobayashi, *Sci. Rep. Tohoku Imp. Univ., Biol.*, 11: 473–485, 1937.

[1] John F. Sheehan and Joyce A. Bruner, *Turtox News*, 23: 65, 1945.

were born from two to five hours short of a full sixteen days from the time of copulation.

Twenty-eight days is probably the youngest recorded age of attainment of sexual maturity in a mammal, as well as in the vertebrates generally.

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CONCERNING THE TERM "RACE DIFFERENCES" AND THE CONCEPT "CULTURE"

WOULD it not serve to clarify the current controversy between Professors Garrett and Herskovits and their respective adherents if those concerned could agree first of all on the meaning of the term "race differences"? Professor Garrett has twice emphasized the fact that "studies in this country over the past forty years have regularly and consistently found differences as between the American Negro and the American White."[1] On the basis of this fact Professor Garrett seems to argue that there are race differences (of a psychological nature), even while admitting that the differences in question are subject to a number of interpretations. Now the very fact that these differences *are* subject to more than one interpretation is what makes most anthropologists unwilling to call them "race differences." Until it can be proved that they are subject to only *one* interpretation—namely, that they are the result of genetically determined biological differences between the two groups compared—it is not justifiable, from the anthropological point of view as regards terminology, to speak of them as race differences.

As for the concept of "culture," anthropologists can hardly have reacted with anything but amazement to Professor Garrett's side challenge to Professor Herskovits for a clarification of this "nebulous concept." There may be some differences of opinion among anthropologists, and particularly among archeologists, as to what constitutes "*a* culture," but certainly there is none as to what constitutes "culture" in general. Lowie's definition is explicit enough:

> By culture we understand the sum total of what an individual acquires from his society—those beliefs, customs, artistic norms, food-habits, and crafts which come to him not by his own creative activity but as a legacy from the past, conveyed by formal or informal education.[2]

So far as I am aware, no question as to the meaning of this concept has arisen in the anthropological literature of the past decade, nor has it come up in seminars or professional meetings.

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SCIENTIFIC BOOKS

MAINSPRINGS OF CIVILIZATION

Mainsprings of Civilization. By ELLSWORTH HUNTINGTON. xii + 660 pp. New York: John Wiley and Sons, Inc. 1945. $4.75.

AS always, in reading a book by Dr. Huntington, the reviewer finds himself torn between admiration for the ingenuity displayed in devising hypotheses to explain vast areas of human conduct and in ferreting out facts which seem to the author to support these hypotheses, and irritation that this ingenuity is not used in testing smaller but more specific hypotheses which are beyond the border of the known but within the realm of the possible in the present state of our knowledge of man's life on the earth.

The "three main principles set forth in this book" (p. 607) are: (a) "that civilization is the unfinished and perhaps never-to-be-finished, product of some great evolutionary force which permeates all nature"; (b) "the action of this force is swayed by three great factors, namely, biological inheritance, physical environment and cultural endowment"; (c) "these three constantly react upon one another, and a knowledge of their combined influence is a prerequisite to a full understanding of history." The reviewer would not hesitate to accept these hypotheses, indeed he can not see how one can do other unless (a) is a reference to some transcendent mystical force which shapes man's destiny willy-nilly, but he feels that what we need in social science is to pin ourselves down to a more specific measurement of the role of each factor in a definite human situation.

There can not be much doubt that in the long course of human development the physical conditions of life have had a selective influence on man's physical and mental make-up. But one finds great difficulty in believing that the qualities Dr. Huntington attributes to Puritans, Parsees, Jews, Armenians, Chinese, Junkers and other "kiths" are biological (hereditary) to the degree he holds. It is true that he makes much of the adaptability of the human race to environmental conditions, but at the same time he seems to believe that the adaptability of the individual within a given cultural group is relatively small, hence, that individual achievement as well as that of the groups

[1] SCIENCE, n.s., 101: 406.

[2] Robert H. Lowie, "The History of Ethnological Theory." New York: Farrar and Rinehart, Inc., 1937.

he has called "kiths" (Puritans, Jews, Chinese, etc.) is determined in a major degree by the heredity of the "kith" and by climate, temperature, ozone, electrical disturbances of the atmosphere and other aspects of physical environment.

The reviewer would be the last one to deny that climate, etc., make no difference in the culture of peoples, that a tropical environment will produce a civilization different from that of Iceland; nor would he question the effects of diet and disease on the energy of different peoples and on their cultural development; but he does not think that Dr. Huntington has proved that these differences in culture are primarily due to hereditary differences induced by physical environment as he seems to believe in spite of his care in calling attention to the constant operation of all three factors.

As a sociologist the reviewer feels that Dr. Huntington has at best but a dim appreciation of the way in which one's cultural environment permeates his every thought and action. This is because Dr. Huntington thinks of culture in terms of a culture of the Puritans or Armenians or Chinese or Junkers or some other "kith" and ignores the family, the neighborhood, the gang and other intimate groups as purveyors of culture to the individual and to smaller groups within the "kith." This failure to understand the relation of the individual to his intimate groups is also the basis of Dr. Huntington's underlying belief that social classes, as manifest in present-day societies, really rest on fundamental hereditary differences, that is to say, have a basis in the natural order and hence can not be disturbed without danger of social deterioration.

Since his search is for physical factors lying beyond man's control (heredity, climate, weather cycles, etc.) which determine his conduct it is not strange that he neglects to a large extent those which lie primarily within his control, his family and community life, his social organization, his economic system, his religious beliefs, etc., and hence falls back largely on physical determinism to explain human conduct.

In the judgment of the reviewer this is a useful book and should be widely read, even though the author sets himself the impossible task of analyzing "the role of biological inheritance and physical environment in influencing the course of history" (p. v) rather than studying their influence in particular situations which might be handled more scientifically.

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PHYSICAL GEOLOGY

Principles of Physical Geology. By ARTHUR HOLMES. xii + 532 pp. 95 pls. 262 text figs. New York: Ronald Press, 1945. $4.00.

THIS is an introductory volume designed for the general reader as well as for students and teachers of geology. The book should appeal to large numbers in each of these groups because it is unusually well written in a clear and forceful style. In organizing his material Dr. Holmes has departed from the pattern ordinarily followed in introductory texts. Recognizing that the various aspects of geology can not be understood or fully appreciated except in relation to the whole and recognizing too that many of his readers may have no prior acquaintance with the subject the author opens his text with a "Preliminary Survey." This part, the first of three, occupies slightly more than one fifth of the volume and is in itself a very readable introduction to geology. Part two is devoted to a more detailed consideration of external processes and their effects, part three to a similar treatment of internal processes and effects. Duplication in the later sections of the book of material given in the preliminary survey is largely avoided by careful writing and the arrangement should be successful in developing and maintaining the reader's interest.

The results of many recent researches, some published as late as 1943, are included. The author's attempts to discriminate between fact and theory are successful in most instances, and several of geology's unsolved problems are deliberately left in an unsettled state.

Innovations are not limited to the broad outline of the subject. There are rather detailed discussions of topics such as the causes of vulcanism, the transmission of earthquake waves and continental drift that usually receive perfunctory treatment in introductory texts. The prominence given to such discussions may explain, in part, the absence of certain types of information that ordinarily are included in beginning texts. Thus, though both coal and oil are given fairly comprehensive treatment, ore deposits are almost completely ignored. The relation of geology to astronomy is mentioned casually, but the customary discussion of earth relations and the origin of the earth are passed over.

The author has admittedly made a special effort to illustrate the text as fully and as effectively as possible. In preparing and assembling the text figures this goal has been achieved. About 200 of the 262 figures are sketches, diagrams and maps that add a great deal to the work, some of them bringing out broad relations in a very striking manner. There are

many excellent structure sections and small-scale tectonic maps. There are, however, no very satisfactory geologic maps, and only in one instance is a structure section accurately tied to a map. At no place in the text did the reviewer find any contour maps or any discussion of contours. Unfortunately many of the photographs are very poorly reproduced. This is due largely, no doubt, to the use of inferior paper in wartime. The text appears to be relatively free of typographic and other minor errors and the index is reasonably complete.

The book has a distinctly cosmopolitan flavor, and examples to illustrate the subjects discussed are chosen from many little known parts of the world. Where not used as a text it should prove invaluable as collateral reading. It is a book, furthermore, that an interested layman can read with great profit.

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GENERAL CHEMISTRY

General Chemistry. By JOHN A. TIMM. Illustrated. xii + 692 pp. New York and London: McGraw-Hill Book Company, Inc. 1944. $3.75.

THIS is one of few really excellent general chemistry text-books; a clear, understandable presentation of orthodox, descriptive general chemistry. It is for the beginner, not the advanced freshman.

Fact and theory are skilfully blended by alternating the descriptive and theoretical material throughout the text; the following content of chapters illustrates this: (1–6) introduction to scientific methods and literature; elements and compounds; a brief statement of atomic theory and molecular weights; balancing equations; (7–8) preparation and reactions of oxygen; fire; (9) valence; (10) hydrogen; (11–12) gas laws and kinetic theory; (13) reactions of oxides; (14–16) liquids, liquefaction and solids; (17–18) chlorine and hydrochloric acid; (19–20) molarity, molality; freezing point depression and other laws of solutions; (21–22) molecular and atomic weights and problems based thereon; (23) halogens; (24) periodic table; (25–29) atomic structure, radioactivity; (30–33) ionization, reaction velocity, protolysis; (34) sulfur and sulfides; (35) precipitation; (36–39) oxides of sulfur, the atmosphere, nitrogen chemistry; (40) oxidation and reduction, electron balancing, electromotive force series, electrode potentials; (41–43) phosphorus family, carbon, boron and silicon; (44) colloidal state; (45–48) electrometallurgy, metallurgy, alloys, alkali and alkaline earth metals; (49) complex salts as illustrated by Cu, Hg, Ag and Au; (50) amphoteric properties as illustrated by Zn, Al, Sn and Pb; (51) oxidation and reduction as illustrated by Fe, Cr and Mn; (52–55) organic chemistry of aliphatic hydrocarbons and their derivatives, aromatics and the chemistry of life, with approximately one page each devoted to coal tars, dyes, plastics, medicines, hormones, photosynthesis, carbohydrates, rayon, fats, proteins, nylon, etc.

Especially commendable are a separate chapter on liquefaction, critical temperature, etc.; a simple arrangement for solving weight and volume problems based on equations; clear-cut emphasis of the importance of Cannizzaro's contribution in interpreting Avogadro's paper; an excellent treatment of light emission and energy levels; probably the most understandable elementary treatment of the Lowry-Bronsted system of acids and bases to be found in any general chemistry text; unusually fine chapters on precipitation, the significance of the electromotive force in oxidation and reduction, and ferrous and non-ferrous alloys. Modern industrial processes are well represented. There are a number of fine photographs, particularly of atomic models.

Sins of omission and commission fortunately are few. Vitamins do not appear in the index, although several pages of vitamin chemistry are given; the old-fashioned fire extinguisher is represented as extinguishing with both water and carbon dioxide, although in reality the latter serves only to eject the former; detergents and a few other topics are missing.

Style is conversational. Such statements as the one on page 42, "Chemistry . . . is far more than a museum of forms, but rather an arena in which interesting and even exciting changes take place," does much to humanize the text and inspire the student.

The author is obviously a teacher of much experience, unusually sympathetic and skilful in training the beginner to learn and to grow in wisdom. He has succeeded in translating these good qualities into his text.

HUBERT N. ALYEA

PRINCETON, N. J.

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